Division of Agricultural Sciences

UNIVERSITY OF CALIFORNIA

# NUTRITIONAL STATUS U.S.A.

Edited by AGNES FAY MORGAN

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CALIFORNIA AGRICULTURAL EXPERIMENT STATION

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## AN INTERREGIONAL RESEARCH PUBLICATION

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The many papers that make up this report were compiled and edited under the supervision of Dr. Agnes Fay Morgan, Professor of Nutrition, Emeritus, and Biochemist, Emeritus, in the California Agricultural Experiment Station, Berkeley.

OCTOBER 1959

# FOREWORD

The value and accomplishments of a voluntary coordinated research program in the field of human nutrition, involving the State Agricultural Experiment Stations of the United States and the Institute of Home Economics of the United States Department of Agriculture, are well demonstrated in the accompanying bulletin.

This research program was stimulated and made possible by the Research and Marketing Act of Congress, later a part of the Amended Hatch Act, which, through financial aid, stimulated the establishment of regional and interregional coordinated and jointly planned research on many problems of importance to agriculture, consumers, and the public health. The research on nutritional status is an example of but one of many such endeavors.

While the federal regional research funds made available to this program served as the financial skeleton around which the research program was built, the states supplemented the federal support with even greater financial assistance from their own funds. In addition, in several states, local and state departments of public health made significant contributions of staff time and facilities. Furthermore, the Institute of Home Economics actively participated in the regional and many state research activities.

The objective of the study reported was to obtain factual information of the nutritional level of the nation by means of sampling appreciable numbers of the population of the United States with reference to such variables as age, sex, geographical location, etc. Never before has a program involving such breadth and depth of information been undertaken. This study will serve as a bench mark for the nutritional status of our people. It would be well if a similar study were made in another five to ten years to determine if the nutritional status of our people is improving or deteriorating. The nutrition of the people is of utmost importance to our well-being as a nation.

Dr. Agnes Fay Morgan of the University of California, Professor of Nutrition and Biochemist in the Agricultural Experiment Station, Emeritus, who was very active in the original research program, was selected by the four regional committees of the United States to analyze and summarize the 178 publications resulting from the work, and to serve as author of the published summary.

PAUL F. SHARP, *Director*
California Agricultural Experiment Station

# CONTENTS

# NUTRITIONAL STATUS . . . U. S. A.

## SUMMARY

What is the nutritional status of the U. S. A.? What does nutritional status mean, can it be measured, and is it good? If it is not as good as we would like what should be done to improve it?

From 1947 through 1958, over 200 professional nutrition investigators devoted a good deal of their time to an attempt to answer these questions. The studies were sponsored by the State Agricultural Experiment Stations, the Institute of Home Economics of the U. S. Department of Agriculture, and several of the state departments of public health. About half of the funds expended by the states were appropriated by the Congress as Federal grants to the State Agricultural Experiment Stations; the remainder was supplied by state funds. The U. S. Department of Agriculture and the U. S. Public Health Service also supplied contributory services. The effort was cooperative within and among the four regions of the U. S. A., the Northeast, North Central, South, and West. The answers to the questions were surprisingly alike in all regions and among all ages and economic groups.

Nutritional status means state of health of the individual or group as conditioned by choice and amount of foods, or more accurately, *nutrients,* eaten. Nutrients are the chemical constituents of foods required by the body for normal growth and function. These are the proteins, carbohydrates, fats, vitamins, and minerals that make up the diet and that are needed every day for our continued well-being.

Children from the age of 5 years through age 12, adolescents from 13 to 20, and adults from 20 to past 80 years of age were examined. About 4000 in each of these three age groups were studied in 39 of the 48 states. Usually there were obtained 7-day records of foods eaten as well as physical examinations and biochemical analyses of blood and urine samples; sometimes elaborate dental examinations and x-rays of bones and teeth. The results were placed on computer cards and interpreted so as to disclose differences, if any, in persons living in various regions, states and local areas, and in persons of different ages and sex by age and sex groupings.

The nutritional status of these citizens of the U. S. A. on the whole was found to be good, probably the best that has ever been reported for any similar population groups. The average nutrient intakes by both the boys and girls up to age 12 in all regions was estimated to be adequate, even *de luxe,* except that the calcium intake of the girls was slightly low. The standards for adequacy were those set up or reaffirmed in 1958 by the National Research Council for recommended daily allowances of nutrients.

Food eaten by boys aged 13 to 20 years on the average provided adequate or more than adequate amounts of all nutrients except vitamin C, but the girls in this age range had food adequate or

high in only 3 nutrients, vitamin A, riboflavin and niacin. The average intakes of the other nutrients by the girls were either seriously low, as for calcium, iron, thiamine and ascorbic acid, or borderline low, as for calories and protein. The diets of the teen-age girls presented the least favorable picture of all those examined.

The number of dietaries of adult men studied was relatively small, only 632, but the number of women was adequate, over 3000. The men had adequate or high average intakes of all nutrients except calories and thiamine, which are related to each other in the recommended allowances mentioned above. The women had good average intakes of all nutrients except calories, thiamine, calcium and riboflavin. The low calorie intakes cannot be cited as a deficit, since these people were by no means on the average underweight. The good intake of the vitamins, mineral and proteins in spite of the relatively reduced total calories points to generally wise food choices.

The nutrients most often found to be lower than the recommended amounts in the diets of children and adults in all four regions were vitamins A and C, calcium and iron.

**What to do about it.** The implications of these occasional low intakes of certain nutrients are important to American agriculture, industry and public health. If it is true that the national eating habits can be criticized because many adolescents and adults have low intakes of ascorbic acid, iron, calcium and vitamin A, what changes in American food choices should be advised? The one major recommendation might be the inclusion of more fruits and vegetables. The choice should be in favor of dark green and deep yellow vegetables, and tomatoes, berries, citrus fruits and melons. These are the sources of vitamins A and C, iron and some calcium. Milk and cheese contribute much calcium and riboflavin and milk fat contributes vitamin A.

Milk solids not fat offer a premium value in nutrition if increase in calorie intake is undesirable. One excellent method of utilizing this valuable food is in bread. Most white bread in our markets contains less than 4 per cent of nonfat milk solids, in terms of flour used, and most whole wheat breads contain none. If the formula were raised to 12 per cent, an important bonus of more than 35 mg. of calcium and 0.1 mg. of riboflavin per slice would be added to the diets, particularly of teen-agers, who use fairly generous amounts of bread and who especially need both these nutrients. Cottage cheese and low-fat milk sherbets also contribute these milk nutrients without much increase in calories, especially from fat.

An increase in the use of fruits and vegetables can apparently produce only favorable results because the calorie load they carry is low compared with their content of valuable nutrients. Even the most calorie sparing diet can be enhanced by their use.

Better cooperation among producers, shippers and merchandisers of these foods is urgently required. Fresh, frozen and canned fruits and vegetables all have their place in this program. But discrimination in favor of the fresh produce is justified as well as in favor of certain fruits and vegetables. Broccoli, green beans and peas, cauliflower, raw cabbage, carrots ,tomatoes, turnip greens and all other greens, apricots, peaches, strawberries, citrus fruits and yellow melons are among the outstanding candidates for recommendation to the American public, particularly to adolescent girls and older women. Anyone can add these foods to the diet without danger of excess calories and to the betterment of the nutrient balance.

**Further evidence of low intakes.** But good average intakes of any population groups may conceal poor choices by some individuals. Intake of nutrients in two-thirds or less the recommended amounts was chosen as representing the borderline of inadequate choice of foods. The percentage of people in the 3 age groups who reported intakes below these amounts is a measure of the extent to which the diets were inadequate.

Except for vitamin C children under the age of 13 years in 6 states, presented generally few cases of low intakes. Diets of 90 per cent or more of these children provided two-thirds or more of the recommended daily allowances of all the nutrients except in New York for iron and niacin, in West Virginia and Iowa calcium, and in Virginia vitamin A. But in all 6 states more than 12 per cent fell short in vitamin C. In the special study of 9- to 11-year-old-boys and girls in Iowa, Kansas and Ohio, 10 per cent or more of the diets provided less than ⅔ of the NRC allowances for calcium and vitamin A as well as vitamin C, especially in the girls' diets. This is not a bad showing, although it indicates areas where improvement is necessary.

The intakes of adolescents 13 to 20 years old were more variable and less favorable, especially those of the girls, than were those of either the younger children or the adults. Of the 26 groups of boys and girls studied in as many states those 13 to 16 years old were examined in 8 Western and 3 Northeastern states. Over 90 per cent of the boys had intakes exceeding two-thirds of the recommended allowances for protein, except for the Spanish American group in New Mexico. More than a fifth of this group of boys and also of the Colorado and Maine boys had diets providing less than two thirds the recommended amounts of calcium, a third were equally low in thiamine, nearly a fifth were low also in niacin, and about half were this low in vitamin C. A much greater proportion of girls lacked these food nutrients to this extent. About 20 to 40 per cent of the girls had diets relatively low in protein, vitamin A, riboflavin, and niacin. More than 50 per cent had diets relatively low in calcium and ascorbic acid among the girls studied in New Mexico, Colorado and Montana. Relatively few of both boys and girls in Oregon, New York and Maine had low nutrient intakes. Only in calcium, vitamin A and vitamin C were there usually more than 10 per cent of the diets in these three states in the low-intake columns.

The young people 16 to 20 years of age in 4 Northeastern, 3 Western states and in Iowa had somewhat better intake records than the younger adolescents. Of the males except in Maine and Colorado more than 90 per cent had diets providing more than two-thirds the recommended allowances of protein and niacin. Forty per cent of the diets in Maine, West Virginia and Colorado fell below this level in calcium and about 25 per cent in Idaho and Colorado in vitamin A and thiamine, but in all 8 states 19 to 80 per cent got less than two thirds the recommended amount of vitamin C. The records of the young women were similar, with large numbers showing relatively low intakes of calcium, iron, vitamin A and vitamin C, especially in Colorado, Idaho and Washington. Riboflavin intake was also low in many of the Maine and Colorado women's diets and calcium in the Iowa diets.

Obviously, the same nutrient deficits occur again and again in all parts of the country in vitamin C, calcium, iron and vitamin A.

Only among the older women in the North Central region were more than 10 per cent of the adults eating less than two-thirds the recommended amounts of protein. In this group, also, more than 20 per cent showed equally low intakes of thiamine and niacin, more than 30 per cent of riboflavin and vitamin C, more than 40 per cent of vitamin A, and more than 50 per cent of calcium. About 10 per cent of the day's meals of the California and Colorado older women were low in niacin, 10 to 20 per cent in thiamine, iron and riboflavin, 20 to 30 per cent in vitamins A and C, and 30 to 45 per cent in calcium. There were few deficiencies in this sense among the diets of the adult men. More than 90 per cent had more than two-thirds the recommended amounts of all the nutrients except vitamin A, calcium and vitamin C. Of the latter, 20 to 40 per cent of every group had low intakes.

**The blood analyses and physical signs.** The blood analyses in general conformed with the values expected from the dietary observations. The physical signs often associated with nutritional deficiencies, such as roughness of skin, inflammation and thickening of mucous membrane of the eyes, swollen and reddened gums, occurred more frequently in the groups with low blood levels of vitamins A and C than in those with satisfactory blood levels. These findings did not, however, always bear out the dietary records of intakes. If facilities were available and one wished to follow one index of nutrition only, analyses for several constituents in the blood may give the best picture of true nutritional status. The hemoglobin content of the blood of nearly all the people examined was fair to excellent and the concentrations of vitamins A and C in the blood serum were generally fair to good.

For example, the New York children under 13 years of age showed a high level of serum vitamin C and a low level of incidence of gingivitis and other signs supposed to be associated with low vitamin C intake. The Virginia and Louisiana children in the same age range had a high incidence of these signs and a considerably lower, though not poor, level of vitamin C in the blood serum. But the average dietary intakes of vitamin C in the two groups of children were about the same. The reason for this discrepancy probably may be found in the fact that the symptoms and blood values reflect long-range dietary habits, while the 7-day diet records can tell only of present and perhaps temporary conditions of food intake.

**Heights and weights of children and adults.** The heights and weights of children and adolescents were measured in several states, particularly in Iowa, Kansas, Ohio, New York, Virginia, Louisiana and several of the Western States. The type of build, growth channels and amount of underweight or overweight for height, age and sex were noted in these groups in most cases, and under- or overweight for height and sex in most of the adults.

There was more underweight than overweight among the Utah children under 13 years of age and, also, among the Louisiana and Virginia children but the New York children in this group had much more overweight than underweight. The 9- to 11-year-old Iowa, Kansas and Ohio school children were fairly well balanced between under- and overweight members, about 10 per cent of each.

More overweight than underweight was seen in the adolescent girls in nearly every group and more underweight than overweight among the boys. The Spanish American and Arizona Indian children had lower average heights and weights than other Western children, except for overweight in the Indian girls.

About 50 per cent of the older women in 5 North Central states were overweight when judged in terms of desirable body weight for persons of their height at age 30. About 30 per cent of those weighed were classed as obese, that is, more than 20 per cent overweight for height. Some 30 per cent of the older California and Colorado women were overweight. About 20 per cent of the California and Colorado men over 50 years of age and 40 per cent of the New Jersey men, 20 to 50 years of age were also overweight. Among the California and Colorado adults, about an equal number with those overweight were underweight, but the North Central women and the New Jersey men had less than 20 per cent who were underweight for height.

The height and weight records of the children corresponded to some extent with the assessment of adequacy of the dietary records and of the blood composition. For instance, the relatively poor diets and low blood levels of vitamins A and C of the Spanish American and Indian children in New Mexico and Arizona, the lower levels of hemoglobin, ascorbic acid and carotene of the Kansas children compared with those in Iowa and Ohio, and of rural compared with town Virginia children bear out the poorer showing in height and weight records of these groups of children.

Strangely enough, however, overweight in adults can not be identified with high calorie intake, indeed the opposite is sometimes the case. Yet checks by weight, analysis of a good many dietary records appear to affirm the accuracy of these records. Of course, accumulated overweight is usually the result of long continued overeating, while the diet record covered only one to seven days. The discrepancy may, also, reflect variations in activity due in part to the use of modern labor-saving devices, continuation of early food habits into the later ages, problems in estimating nutrient value of the food eaten, and perhaps in actual efficiency of energy transformation. Thus, the low calorie diets may still exceed calorie needs. This may mean that energy requirements, especially of older women, need to be studied further.

# PART I

## SECTION 1

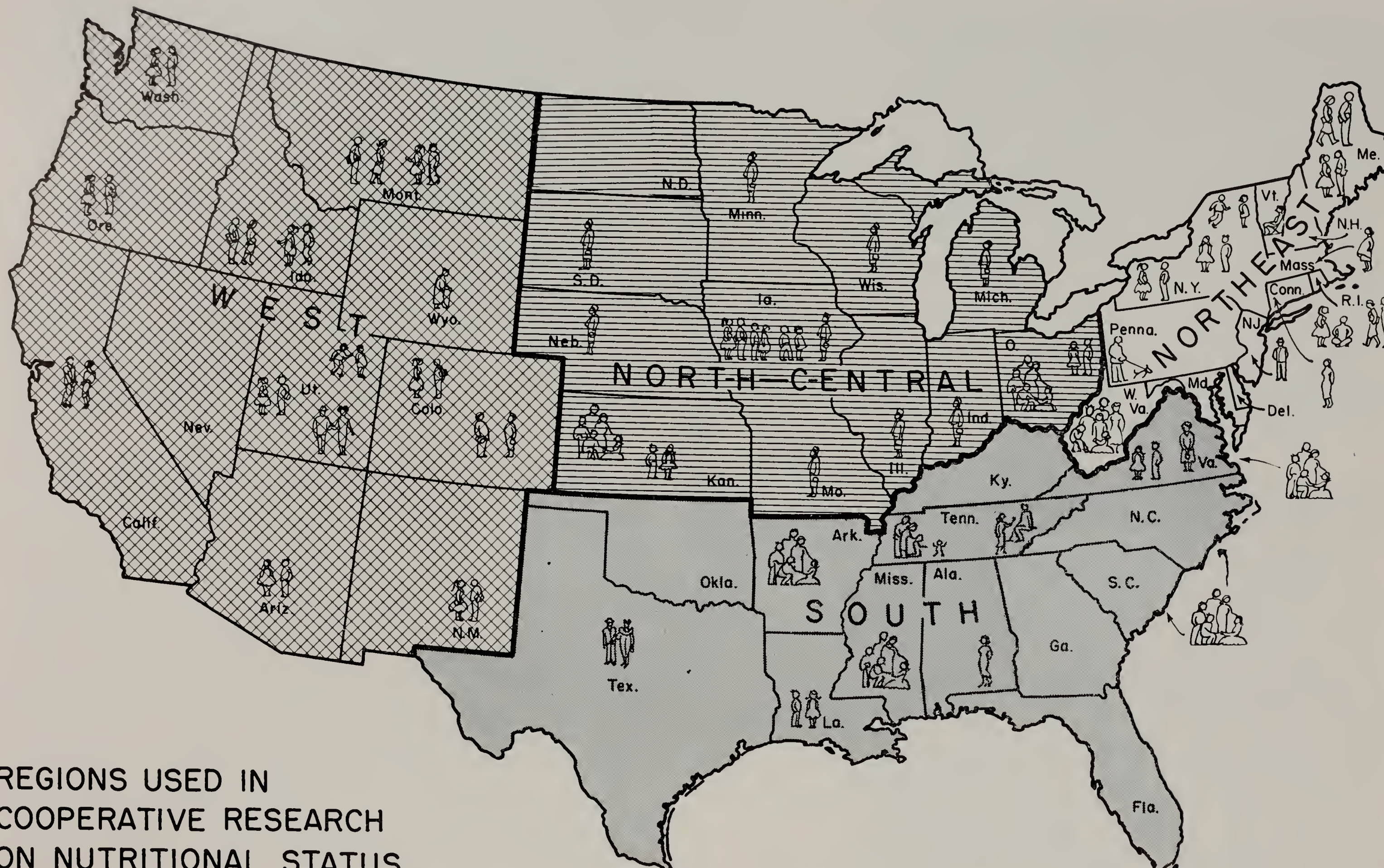
## How to Get Reliable Food Records

**How good is the American diet?** Are Americans well fed? What foods do they eat, how much and how good are the nutritive values of these foods? How do various age groups differ in the quantity and value of the foods they choose? Do the people of the West, South, Northeast, and North Central regions differ in their food patterns? What is good and what needs improvement in these food patterns so far as scientific findings up to now can determine? Do the blood composition, the physical growth of children, the height and weight of adults, the condition of skin, eyes, gums, tongue, teeth and bones reflect the good or deficient nutritional quality of the foods usually consumed? How much difference would improvement of these patterns make to the public health? Agriculture and the food industries are concerned with these questions as well as nutritionists, educators and consumers.

These are some of the questions which the state experiment stations set out to answer in a 10-year cooperative study of the nutritional status of selected population groups in all parts of the country.

In each of the four regions, coordination of purposes and methods was secured by means of a technical committee containing one member from each state and a member from the Human Nutrition Research Branch and the office of Experiment Stations, USDA. Aside from these agreements, each state was completely independent as to choice of groups to be studied, size of the sample, and interpretation of results. In some of the regions the data were pooled and a regional report was issued.

But many other individual studies of local or incidental as well as of fundamental problems were tackled by the states, and some of these are sketched in later chapters.




REGIONS USED IN
COOPERATIVE RESEARCH
ON NUTRITIONAL STATUS

## DISTRIBUTION OF SUBJECTS OF NUTRITIONAL STUDIES IN 39 STATES

| *Region* | *States* | *Age and Sex* | *Number* |
|---|---|---|---|
| Northeast | Connecticut | Adult women | 91 |
| | Maine | Children under 13 | 12 |
| | | Boys and girls 13-15 | 208 |
| | | Boys and girls 16-20 | 46 |
| | Massachusetts | Pregnant women 16-35 | 79 |
| | New Jersey | Men 20-50 | 606 |
| | New York | Children under 13 | 265 |
| | | Boys and girls 13-15 | 222 |
| | | Boys and girls 16-20 | 19 |
| | Pennsylvania | Young adult men | 22 |
| | Rhode Island | Boys and girls 13-15 | 59 |
| | | Boys and girls 16-20 | 237 |
| | Vermont | Young women | 49 |
| | West Virginia | College students 16-20 | 181 |
| | | College students over 20 | 154 |
| | | Children under 13 | 1111 |
| North Central | Illinois | Women over 30 | 505 |
| | Indiana | Women over 30 | 28 |
| | Iowa | Women over 30 | 1116 |
| | | Children under 13 | 808 |
| | | Boys and girls 13-18 | 380 |
| | Kansas | Boys and girls 9-11 | 645 |
| | | Families | 178 |
| | Ohio | Boys and girls 9-11 | 710 |
| | | Families | 268 |
| | Michigan | Women over 30 | 115 |
| | Minnesota | Women over 30 | 120 |
| | Missouri | Women over 30 | 15 |
| | Nebraska | Women over 30 | 297 |
| | South Dakota | Women over 30 | 339 |
| | Wisconsin | Women over 30 | 68 |
| South | Alabama | Adult women | 12 |
| | Arkansas | Families | 126 |
| | Louisiana | Children 8-11 | 532 |
| | Mississippi | Families | 330 |
| | North Carolina | Families (statistics) | 731 |
| | South Carolina | Families | 297 |
| | Tennessee | Men and women 19-25 | 20 |
| | | Families | 122 |
| | Texas | Adults | 9 |
| | Virginia | Children 8-12 | 219 |
| | | Women 20-50 | 230 |
| | | Families | 252 |

## DISTRIBUTION OF SUBJECTS OF NUTRITIONAL STUDIES IN 39 STATES

| *Region* | *States* | *Age and Sex* | *Number* |
|---|---|---|---|
| West | Arizona | Boys and girls 12-16 | 115 |
| | California | Men and women over 50 | 577 |
| | Colorado | Men and women over 50 | 175 |
| | | Boys and girls 13-18 | 162 |
| | Idaho | Boys and girls 14-17 | 274 |
| | Montana | Boys and girls 13-15 | 221 |
| | | Boys and girls 16-20 | 197 |
| | New Mexico | Boys and girls 14-17 | 168 |
| | Oregon | Boys and girls 14-17 | 739 |
| | Utah | Children under 13 | 141 |
| | | Boys and girls 13-18 | 59 |
| | | Men and women 25-49 | 41 |
| | Washington | Boys and girls 14-16 | 247 |
| | Wyoming | Women over 60 | 70 |

**Sampling.** A most important point to remember in evaluating the results of these surveys concerns the sampling. Since the results recorded in this bulletin are identified solely by the names of the states in which the data were gathered, it may be misleading to the reader if the type of sampling or selection of subjects is not described.

In the extensive North Central study of older women, the sampling was set forth clearly, as noted later. The adolescents in the Western states were chosen to represent certain geographical areas, as in Oregon and Washington, or cultures, as in New Mexico and Arizona. The older men and women in California and Colorado were chosen from volunteers in selected communities, the object of the study being a search for correlations between diet and blood composition and physical condition rather than assessment of a population.

In the Northeast, the same objective, that is, discovery of correlations between diet and blood composition and medical findings, was set up, and the sampling of the population was therefore devised not for statistical purposes but for convenience of access. Generally, the subjects were those of the designated age and sex in the communities where the experiment stations are located.

**Choice of method of obtaining food records.** Two of the regions, the Northeast and North Central, made a critical examination of the methods to be used in collecting the information on kinds and amounts of food eaten. At least four methods seemed to be available. These were 1) the securing of a detailed history of food intake, likes, and dislikes by interview; 2) records voluntarily kept by the subjects for one or more days; 3) recall by the subjects of foods eaten one or more days previously; 4) records of weighed food intake kept by the nutritionist or by the subject.

Everyone agreed that records of weighed food intake were most likely to be reliable, but the likelihood of obtaining many of these records was not great. The interview and dietary history might be expected to yield data of value, but it might not represent the actual present-day practices of the subject. If the subjects keep records of food eaten or if they recalled the food intake of the day before, how many and which days should be used? Should children's records be kept by themselves or by their mothers? The margin of error in obtaining a true story of an individual's food intake by any of these methods and also the error for a group's intake had to be established. How many subjects are required to obtain a given amount of precision? How do season, ethnic origin, and economic level affect the food intakes? Standard measures or servings should be recorded if the foods were not weighed, and accurate estimates made of these measures. How accurate are the tables of food composition used by the nutritionist to convert food quantities into nutrients (the chemical food constituents needed by the body)?

The Northeast region undertook to find answers to some of these questions. Their subjects included school children of all ages, college students, pregnant women aged 16 to 35, and male industrial workers up to age 50. In the North Central region similar comparisons were made using older women and school children.

**Numbers of subjects and days.** By the use of statistical procedures the Northeast group was able to evolve a chart showing the number of subjects required to obtain a given degree of precision with the 1-day dietary record and the number of days required for a given number of subjects. They found the records kept by females enough more accurate than those kept by males to allow the use of 5 per cent fewer female subjects to obtain the same degree of precision in the data. Some of the nutrients, for example, vitamins A and C, were represented so variably in the diets that 10 per cent more records were required to obtain a clear picture of ascorbic acid intake, and vitamin A intake was not reasonably estimated at all by the use of this chart.

**What days?** Most children and college students ate less over the weekends than on the other days of the week. But the records of 150 adults showed little difference between weekends and other days. In the North Central region school children were found to consume more protein, perhaps as meat, and less calcium, probably in milk, over the weekends than during the school days.

**How many days?** Most of the surveys adopted the 7-day dietary record, but some used the 24-hour record or recall. The dietary interview and history were also obtained in hundreds of cases. A few subjects kept dietary records for 1, 3, 14, and 28 days in order to compare the reliability of these records.

The dietary history almost invariably recorded more favorable food intakes, that is, more nearly like the recommended daily allowances, than the actual food diaries kept by the same subjects. On the other hand, the 1-day recall interview and the 7-day dietary record were fairly well in agreement. It was concluded that the 1-day recall could be used to determine the characteristics of the food use of *groups* but that a 14-day record was needed for a fair estimate of the intake of an *individual.*

The North Central region, studying school children in Iowa, Kansas and Ohio, concluded that no rule of thumb could be adopted but that a preliminary survey is necessary to determine the method of choice in each case. They found 1-day records to yield a greater number of so-called good diets than did the 3-day diet records and these, in turn, more than the 7-day records.

**Effect of season.** The North Central studies of school children were carried out in spring and fall. Three-day records kept by 9-, 10- and 11-year-old children in Ohio and Kansas showed that intake of ascorbic acid (fruits and vegetables) was greater in the spring than in the fall and that of protein (meat, milk, eggs) greater in the fall. However, in two of the studies in the Northeast no significant difference in nutrient intake of children could be ascribed to seasonal influences.

**What kind of record?** Interviews by a skilled nutritionist preceded or followed the record period in most cases. Estimates of size of food portions by weight, by household measure, or by use of models, were taught the subjects, and in some cases the records were checked in this manner also. The estimates of size of servings made by the subjects were checked by weight, and the conclusion reached that estimates on a group basis are not more than 20 per cent wrong, children excepted. College students of home economics, homemakers, male industrial workers, other college students, and junior high school students were accurate in these estimates in the order given. Of course, quantities of some foods, such as bread, rolls, milk, soup, eggs, and suger, were easier to estimate than others.

**Size of servings.** The North Central region recorded the weights of servings of most common foods eaten by 242 women, 30 to 92 years of age, in six states. Some 3170 daily records of weights of foods eaten were examined and fairly consistent averages obtained for size of servings of 15 kinds of meat, 12 vegetables, 7 kinds of cooked potatoes, 8 fruits, bread, table fat, sugar and cream added to cereals or fruit, and beverage milk.

The women over 70 years of age chose smaller portions of nearly all foods than did the younger women, but used somewhat more sugar, cream, and butter or margarine. In general, there were no great differences in size of servings among the women living in the six states participating in the study. The authors suggested that the somewhat larger servings of beef and poultry in Nebraska and of fish in Michigan may be connected with the beef, poultry, and fish production in those states. The South Dakota and Iowa women ate the smallest portions of ground beef, and the Michigan and Wisconsin women the largest. The South Dakota women also ate smaller servings of vegetables, including potatoes, than did the subjects in Iowa, Michigan, Minnesota, and Nebraska.

The average serving weights found in this study may be valid only for the women in the age range used. Also, it should be noted that 18 subjects in Michigan contributed 40 per cent of the dietary records, since they carried on the experiment for 70 days instead of the 4 to 17 days used by the other state groups.

**Accuracy of food calculations.** To test the reliability of calculated values for the important constituents of foods, the Massachusetts station weighed and analyzed all the food eaten by 21 subjects for one day and compared the results with the figures obtained by calculation from standard tables of food composition. The figures for protein, calcium, phosphorus, thiamine (vitamin $B_1$), and niacin were practically the same whether found by analysis or by calculation, but the fat and ascorbic acid were generally higher and the riboflavin (vitamin $B_2$) lower in the calculated than in the analyzed data. Fat and ascorbic acid are the nutrients most likely to be lost from foods during cooking. This raises the question of the reliability of the standard tables of composition of cooked foods. In any case the tables used were the same in nearly all the studies.

The New Jersey station developed a simplified method of calculating the nutritive value of dietaries, which was adopted by the Northeastern cooperators. This involved the direct expression of food composition values as percentages of the recommended dietary allowances (see Section 4). No appreciable loss of accuracy resulted from the use of this time-saving device.

**The recommended method.** The conclusion was that records of quantities of food eaten by the inidviduals should be procured as accurately as possible and these should then be subjected to calculation from standard tables of composition for raw and cooked foods, to show the amounts of nutrients, that is, calories, protein, vitamins and minerals, which the individuals obtained. Evaluation of diets by checking against amounts of certain food classes, "the basic four or seven" for example, was rejected as inadequate by itself, since good diet can be achieved in many diverse ways.

As will be shown later, no strict uniformity of dietary recording was achieved in these nation-wide studies. Most of the surveys, however, were made by the 7-day food-diary method, although the Northeast study group recommended the one-day recall method as more efficient and equally accurate for determining the food patterns of a group. The choice of day of the week they thought unimportant and for the one-day study they thought the written record or recall equally acceptable. They also found that all trained nutritionists procured diet histories and records of comparable accuracy and calculated their nutritive values similarly.

## SECTION 2

## Family Food Consumption Records

The individual dietary records which have hitherto been discussed differ markedly from the family food-consumption records which have been used by the U. S. Department of Agriculture for many years. In the latter, an accurate inventory of all food in the house is made at the beginning and at the end of the test period, usually one week, and of all food brought into the kitchen during this period. To get the average consumption of food per person, the quantity of food which disappeared is divided by the household size in equivalent persons. The number of equivalent persons is obtained by dividing the number of meals served to all persons in the household by twenty-one.

"After the nutritive value of the family food supply is calculated, averages per nutrition unit or adult male equivalent are computed. The number of nutrition units or man-equivalent of the families is obtained by estimating how many times the recommended allowance of a given nutrient for a man 25 years of age is needed by all the members of the family. For example, based on the 1958 revision of the National Research Council's recommended dietary allowances, a family having a father and mother, each aged 35 years, 2 sons aged 8 and 12 years, and 2 daughters aged 4 and 14 years, would have 5.5 man-equivalents for protein, riboflavin and ascorbic acid; 4.4 for calories and thiamine; 4.6 for niacin (equivalent); 7.6 for calcium; and 6.7 for iron."

A second method used in food-consumption surveys is the recall-list method. The investigator obtains from the homemaker a complete report of all the foods used by the family during some immediately previous period, usually one week. A detailed list and careful questioning are required in this process. The listing is much less expensive than the weighed record but may also be less accurate. It is usually possible, however, to obtain better cooperation from all families drawn in the sample when the recall list schedule is used.

The Food Consumption studies in the South in 1947-48 were done by the food record method and were devised not only to learn the kind and nutritive value of foods eaten by families in various farming areas and at various income levels but also to record the cash values and home production and preservation of these foods. Such studies, either the recall-list or record type, have been carried out on a large scale by the U. S. Department of Agriculture for many years with two purposes: 1) To find out the nation's food habits and its probable dietary level, and 2) to determine the market for the farmer's product. The latest of these gigantic efforts was made in 1955 and covered the food consumption of over 6,000 families in both cities and rural districts in all four regions of the country. It is interesting to make a comparison of some of these findings of food disappearance and man-day apparent consumption of nutrients with the actual daily intake records of more than 9,000 individuals of nearly all ages studied by the experiment station workers in the cooperative regional nutritional status researches here reported.

Mississippi and South Carolina workers collaborated with the Bureau of Human Nutrition and Home Economics in a comparison of the record and list-recall methods of obtaining food consumption data. They worked in two farming areas with negro sharecropper families in Mississippi and with both white and negro families of farm owners and cash renters in South Carolina. Carefully chosen comparable families in each of the states were induced to make records of food consumption or to answer the recall-list questions on the same subject. There were from 68 to 97 families in each of the groups in the two states, 177 using the lists and 161 the records. In both states, aside from minor differences usually not statistically significant, the two methods of investigation yielded nearly the same results. Ascorbic acid (vitamin C) and vitamin A were the two nutrients which showed the greatest differences in average intakes as recorded by the two methods. This may be due to the same variability of intake seen in the critical Northeastern studies of individual dietary records. However, some bias in the lists was seen, particularly with respect to "prestige" foods such as oranges. By the record, the average consumption in pound of the Mississippi families per household per week of tomatoes and citrus fruit was 1.40, but by the list 3.42. Consumption of other food groups, such as meat, eggs, grain products, other fruits and vegetables, fats, and milk, differed but little. If the prestige bias of this group is eliminated, the ascorbic acid and vitamin A intake of the two groups become comparable.

The amounts in pounds per week per adult man-equivalent, consumed by the Southern families in the three farming areas were found to be: meat, poultry and fish, 1.5 to 2.1; eggs, 0.4 to 0.6; legumes, 0.34 to 0.64; milk, 5.4 to 12.7; cereal products, 4.4 to 4.8; fats, 1.2 to 1.4; potatoes, 1.16 to 2.59; vitamin-rich fruits and vegetables, 1.2 to 2.2; other fruits and vegetables, 1.0 to 3.1; sweets and desserts, 1.10 to 1.68. The quantities used in the various farming areas are shown in figure 1.

Compared with the amounts found in a similar study conducted in Kansas and Ohio (fig. 2), the intakes in the Southern states of meat and other protein food, as well as of milk, fruits and vegetables, were low, averaging 30 per cent lower for meat and milk and 60 per cent lower

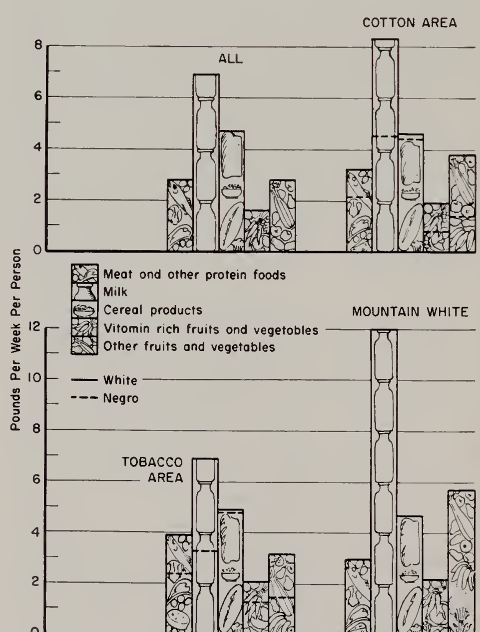



**Fig. 1. Consumption of five food groups in pounds per person per week, by low-income families in three areas of the South.**

for fruits and vegetables. The bread and cereal intake in the South was about 30 per cent higher than in the two North Central states, the fat intake about the same, and sweets and desserts about 20 per cent lower. Of course, the Southern families were living in rural areas and were all in the lowest income groups, but 58 per cent of the Kansas and 30 per cent of the Ohio families were classified as rural. Also, 32 per cent of the Kansas and 15 per cent of the Ohio families had incomes of less than $3,000 per year, but only 4 per cent of Kansas and 15 per cent of Ohio families had less than $2,000. On the other hand, all families in the Southern study lived in rural areas and the average net income was about $1,500 per year. In the South a household averageed six persons, but three-fourths of the Kansas and Ohio families had less than six members. It was evident in both studies that quantity of foods and adequacy of diets were lower in rural, low-income, and large families than in the urban, medium- and high-income, and smaller families. No fair comparison therefore can be made between the Southern and North Central family food-consumption studies. Nevertheless, the 1955 U. S. Department of Agriculture food-consumption figures for a representative group of families in all four regions, as shown in table 1, indicate somewhat the same but less drastically different patterns of food intake between the South and the other three regions.

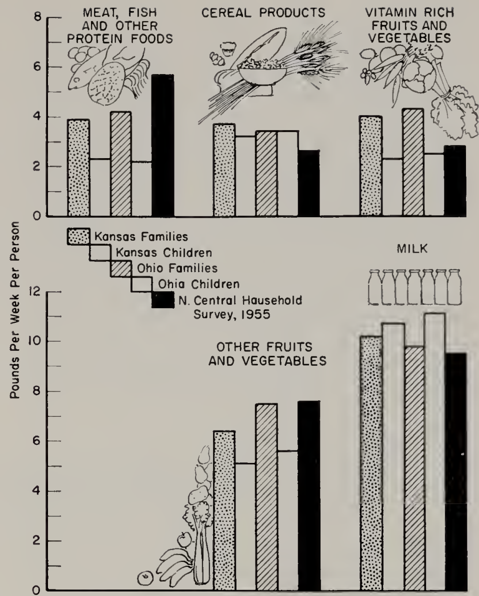



**Fig. 2. Comparison of consumption records of five food groups in pounds per person per week, by Kansas and Ohio families and by their 9- to 11-year-old children. Consumption data for Kansas and Ohio families are comparable with those of the 1955 North Central household survey, but the children's records are not comparable with the latter.**

The North Central family food-consumption study included in the cooperative projects was made in Kansas and Ohio in connection with the critical study of the nutritional status of school children in Kansas, Ohio and Iowa. The recall-list method was used and an effort was made to compare the family consumption of foods and nutrients with the

**TABLE 1.—USDA Food Consumption Survey, 1955.**

| Region | No. of Families | Meat, Poultry, Fish, Eggs, Legumes | Milk | Cereal Products | Vitamin-Rich Fruits & Vegetables | Other Fruits & Vegetables including Potatoes |
|---|---|---|---|---|---|---|
| | | pounds / person / week | | | | |
| Northeast | 1,262 | 5.47 | 9.72 | 2.21 | 2.93 | 7.23 |
| North Central | 1,385 | 5.56 | 10.23 | 2.59 | 2.80 | 7.72 |
| West | 527 | 5.78 | 10.43 | 2.60 | 2.80 | 7.70 |
| South | 1,381 | 4.98 | 8.56 | 3.69 | 2.14 | 6.29 |

individual 3-day dietary records of the 9- to 11-year-old children of these families. The family-consumption records in all cases presented a more favorable picture than did the children's records. The reason for this is chiefly that *all* food, disregarding waste, was included in the family records, whereas in the children's records only the food eaten was reported.

As shown in figure 2, the amounts of meat and other protein foods as well as fruits and vegetables consumed per "nutrition unit" that is, per person, by the families were almost twice those reported in the children's individual records, but the amount of milk taken by the children was slightly higher and that of the cereal products was about the same. This may mean that the children ate less meat, fruit and vegetables and more milk than other members of the family, or it may mean that in the family records the amount of waste or overestimate was greater for meat and similar protein foods and for fruits and vegetables than for the other foods reported. In any case,

**TABLE 2.—Average Nutrient Intakes of 446 Families in Kansas and Ohio and of 9- to 11-Year-Old Children of These Families.**

| State | Method of Study | Nutrients Per Day | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Calories | Protein—gm | Calcium—gm | Iron—mg | Vitamin A I U X1,000 | Thiamine—mg | Riboflavin—mg | Niacin—mg | Ascorbic Acid—mg |
| Kansas | Family consumption | 3,974 | 104 | 1.14 | 17 | 10.15 | 2.3 | 2.7 | 24 | 111 |
| | Boys | 2,220 | 79 | 1.08 | 13 | 6.69 | 1.3 | 2.0 | 13 | 70 |
| | Girls | 2,210 | 75 | 1.01 | 12 | 7.49 | 1.3 | 2.0 | 13 | 79 |
| Ohio | Family consumption | 4,017 | 108 | 1.10 | 19 | 10.33 | 2.5 | 2.7 | 26 | 133 |
| | Boys | 2,420 | 81 | 1.19 | 14 | 7.65 | 1.8 | 2.5 | 16 | 85 |
| | Girls | 2,116 | 72 | 1.07 | 13 | 6.26 | 1.6 | 2.0 | 14 | 77 |
| Recommended Allowances | Children 9-11 years | 2,250 | 65 | 1.1 | 11 | 4.00 | 1.1 | 1.7 | 12 | 65 |
| | Families (man-equivalent) | 3,200 | 65 | 0.8 | 12 | 5.00 | 1.6 | 1.6 | 16 | 75 |
| Percentage of families and children with less than ⅔ allowance: | | | | | | | | | | |
| Kansas | Families | 0 | 1 | 7 | 0 | 3 | 0 | 0 | 0 | 3 |
| | Boys | 14 | 7 | 31 | 10 | 17 | 8 | 10 | 18 | 41 |
| | Girls | 13 | 8 | 33 | 7 | 13 | 5 | 11 | 14 | 35 |
| Ohio | Families | 1 | 1 | 9 | 0 | 5 | 0 | 1.5 | 0 | 4 |
| | Boys | 6 | 3 | 16 | 6 | 18 | 5 | 5 | 6 | 33 |
| | Girls | 11 | 5 | 25 | 11 | 26 | 7 | 7 | 9 | 31 |

there appears to be a discrepancy on the optimistic side in the food-consumption studies of families.

Another measure of food intake, and a most important one, is the estimate of the nutrients, that is, calories, protein, minerals, and vitamins, obtained by families or children. As shown in table 2, the average amounts of 9 nutrients consumed per person by the Kansas and Ohio families and by the children of these families are ample in every case except calcium. The amount of calcium is slightly lower than the quantity recommended as a generous allowance by a committee of the National Research Council in 1953, but doubt has frequently been expressed as to the validity of this recommended allowance.

But averages may be misleading in that some families and children may have had too low, others too high, amounts of nutrients. If we regard two-thirds or less of the recommended allowances as borderline for nutritional safety, the percentage of families and children whose diets were this low in some or all of the nutrients, is of interest. In both states the proportion of families with borderline intakes of any of the nutrients is very small, 0 to 7 per cent in Kansas and 0 to 9 per cent in Ohio. But the percentage of children in this group is much higher, respectively, 5 to 41 per cent in Kansas and 3 to 33 per cent in Ohio. Of the children in both states, 32 and 20 per cent had diets low in calcium, 38 and 32 per cent low in ascorbic acid, 15 and 22 per cent low in vitamin A, 4 to 16 per cent low in the other nutrients. Again, it is evident that family consumption records tend to show larger food quantities and nutrients available to and presumably consumed by family members, especially children, than do the individual records. There is no cause for complacency in these figures.

This comparison of the total nutrients reported as available for consumption in the economic sense by the families per man-equivalent with the amounts of these nutrients eaten by the children according to their own individual records is of practical interest.

The average amount available for consumption per person per day of calories, protein, and the other nurients recorded for the families can be compared with the average intakes of these nutrients reported by the children of these families. If the latter are expressed as percentages of the average per-man per-day intakes of the families (fig. 3), it is evident that the children ate only 55 to 70 per cent of the calories, niacin, thiamine, and ascorbic acid; 65 to 75 per cent of protein, iron and vitamin A; and 75 to 108 per cent of the calcium and riboflavin credited per person per day to the families.

Because the children had more milk and nearly as much cereal food as the average per person in the families, the discrepancies in riboflavin, calcium, vitamin A, and iron were less than in the other nutrients, that is, protein, thiamine, niacin and ascorbic acid, which were largely supplied by the meat, vegetables

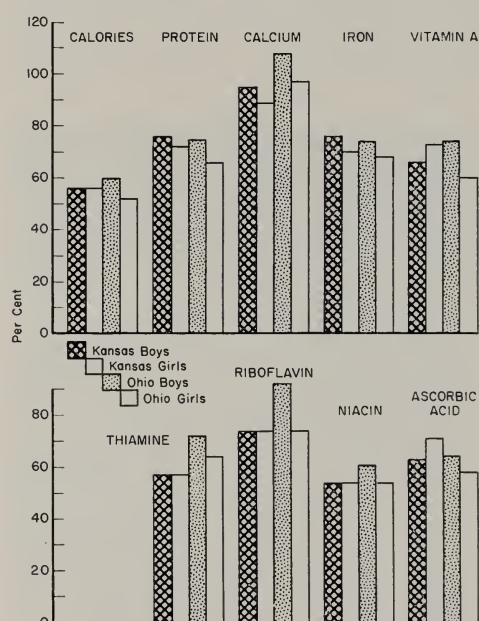



**Fig. 3. Percentage of Kansas and Ohio household food consumption per person of nutrients reported as eaten by children 9 to 11 years of age of those families.**

TABLE 3.—Average Nutrient Intakes Per Person (Man-equivalent) of 730 Low-Income Rural Families in Five Southern States.

| Description | No. of Families | Calories | Protein—gm | Calcium—gm | Iron—mg | Vitamin A I U X1,000 | Thiamine—mg | Riboflavin—mg | Niacin—mg | Ascorbic Acid—mg |
|---|---|---|---|---|---|---|---|---|---|---|
| Cotton areas: | | | | | | | | | | |
| White | 107 | 3,220 | 88 | 1.2 | 20 | 6.1 | 2.3 | 2.4 | 18 | 76 |
| Negro | 201 | 2,490 | 63 | 0.8 | 16 | 3.9 | 1.9 | 1.6 | 15 | 51 |
| Tobacco areas: | | | | | | | | | | |
| White | 157 | 3,100 | 90 | 1.1 | 18 | 7.3 | 2.4 | 2.2 | 18 | 86 |
| Negro | 144 | 2,490 | 66 | 0.7 | 15 | 5.2 | 1.9 | 1.5 | 15 | 66 |
| Mountain areas: | | | | | | | | | | |
| White | 121 | 3,450 | 98 | 1.4 | 20 | 5.6 | 2.3 | 2.6 | 16 | 83 |
| Percentage with less than ⅔ recommended: allowances: | | | | | | | | | | |
| All white | | <1 | <1 | 20 | <1 | 13 | 0 | 3 | <1 | 15 |
| All Negro | | 6 | 8 | 37 | 2 | 18 | 0 | 21 | 3 | 25 |

and fruits which were eaten in smaller amounts by the children. The remaining large percentage of children who had less than two-thirds of the recommended amount of calcium (table 2) is difficult to explain in view of the fair level of milk intake. Of course, this may indicate merely an uneven distribution of milk drinking, nearly one-third of the children with small intakes, the rest with disproportionately large intakes.

A similar picture of nutrient values in the diets of the Southern families is shown in table 3. Obviously, the negro families had diets of lower nutritive value than the white and there were more negro families with less than two-thirds the 1953 recommended allowances. The chief deficits in both groups were in calcium, vitamin A, and ascorbic acid. This is the same story told again and again in these dietary records. While there may be some question about the vilidity of the calcium deficits, the vitamin A and ascorbic acid deficits are probably factual and point again to the lack of adequate amounts of vitamin-rich fruits and vegetables, as shown in figure 1. If the calcium deficit is included, milk was the next most important food used in too small amounts by these Southern families.

The general conclusion from these family food-consumption studies is plain. Some families on low-income levels, both white and negro, have diets that are deficient in important nutrients because they consume too little milk and vitamin-rich fruits and vegetables. Also, when family food-consumption records are compared with the children's individual food diaries, the picture appears less favorable. The children eat less meat, fruits, and vegetables, the same amount of bread and cereal foods, but more milk than the average available for consumption per person in the families. The children's diets suggest significant percentages of low intakes of some important nutrients, chiefly ascorbic acid, vitamin A, and calcium. Indeed, when the family diet was reckoned to be adequate, only 15 per cent of the children's diets met 100 per cent of the recommended daily allowances of nutrients.

Thus, evidence of ample supplies of foods and nutrients available in households is no guarantee of ample intake by all members, particularly the children.

## SECTION 3

# How Much of What Foods Was Eaten?

Some of the reports on dietaries gave quantities of certain food groups eaten by children and adults in pounds per week. These calculations of individual intakes which do not include plate or kitchen waste, differ rather strikingly from the "availability" or "disappearance" figures reported in the USDA family or household surveys. Both kitchen and plate waste are included in the latter. On the other hand, the kitchen inventory or recall-list method used in the surveys may have produced somewhat less variable and more accurate data than the individually kept records, particularly those kept by children. In the household survey overestimates and underestimates may tend to balance but the individual diet record is more likely to err on the side of omission.

Some of the figures quoted in the tables were obtained by recalculation from calorie values from the food groups quoted by the original reporters, and these in turn were often calculated from the reported number of "servings" of the foods. As noted previously, a good deal of effort was made to ensure agreement on the size of servings and on the nutrient value of the foods included. In some cases records which were obviously interpreted differently from the majority, although probably valid in themselves, were not included.

In the Northeast only seven food groups were presented in this fashion: 1) bread and breadstuffs; 2) fluid milk; 3) citrus fruits; 4) eggs; 5) meat, poultry and fish; 6) Irish potatoes; 7) vegetables and tomatoes. These seven foods contributed about 50 per cent of the total calories consumed by the 778 persons who kept the 7-day diet records but between 55 and 70 per cent of the protein, vitamins and minerals.

### Iowa, Kansas and Ohio children.

In the North Central region a pilot study of Iowa, Kansas, and Ohio school children, 9 to 11 years old, yielded estimates of the average number of servings per day of six foods taken by 76 children. These foods were 1) leafy green and yellow vegetables; 2) vitamin C-rich foods, such as tomatoes and citrus fruits; 3) other fruits and vegetables; 4) milk; 5) protein-rich foods, such as meat, poultry,

**West Virginia University students check their lunches.**

fish, eggs, legumes; and 6) cereals. In a later, more comprehensive study of children in these three states the three-day diet records of more than 1700 children were analyzed. The sample was chosen so as to be statistically representative of the population centers in the three states. Again the average number of servings per day of the six food groups was calculated. Also, the records of a representative group of children in each state who ate the lunch provided by the schools were compared with those of a matched group who did not take the officially provided school lunch. The nutrients obtained by the children were calculated from these records. In figure 4 it is seen that both groups of these children took daily on the average 1½ pints of milk, somewhat less than 5 ounces of meat or other protein food, about eight ounces of breads and cereals, and 10 to 18 ounces of fruits and vegetables, only 30 to 40 per cent of which was of the vitamin-rich types. The boys ate more than the girls except in Kansas where the girls consumed more milk and fruits and vegetables than the boys. The Ohio children ate larger amounts of nearly all the foods thn did those in Kansas and Iowa.

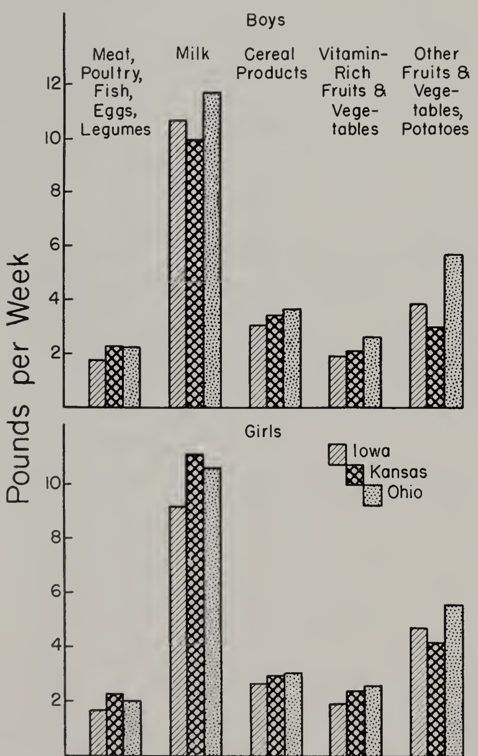



**Fig. 4. Consumption of five food groups in pounds per week by children in Iowa, Kansas, and Ohio, 9 to 11 years of age.**

### North Central, Utah, and Louisiana children.

A group of 45 children aged 8 to 11 years in Louisiana on the average ate per day 3½ to 4½ ounces of meat or other protein-rich food, 1.1 pints of milk, 3 ounces of cereal or bread, and 11 ounces of fruits and vegetables, 30 per cent of which were of the vitamin-rich type (fig. 5). All these quantities are significantly smaller than those eaten by the Iowa, Kansas, and Ohio children 9 to 11 years old as well as by Utah children 5 to 12 years of age.

The Iowa children ate more meat and other protein foods, more milk, about the same amount of vitamin-rich fruits and vegetables, more "other" vegetables and fruits, and less cereal, sweets, and desserts than the Utah children. The Utah children in turn had more of all these foods except vitamin-rich fruits and vegetables than did the Louisiana children. Obviously bread and other cereal products, sweets, and desserts had a larger place in the diets in Utah than in Iowa, with correspondingly less meat, eggs, milk, fruits and vegetables. This resulted in more deficits of certain nutrients for the Utah than for the Iowa children, e.g., iron, vitamin A, niacin and ascorbic acid. (See fig. 43, Section 6.)

### The adolescents' intakes.

In the West, aside from the small groups of children 5 to 12 years of age studied in Utah, boys and girls 13 to 20 years of age were the chief participants. As shown in table 4, these adolescents in three states, Montana, Idaho, and Oregon, ate in general more milk, less potatoes, more cereals, and less meat and other protein-rich foods than did the corresponding age group in New York, Maine, and West Virginia.

In figure 6 is shown the food consumption of boys and girls 13 to 20 years old in Iowa, four Northeastern and three Western states. The Western subjects again reported less meat and other protein foods, more milk, and more cereal products than the Iowa and Northeastern groups. Consumption of fruits and vegetables was about the same in all regions, except for the 16-to 20-year-old West Virginia students, who ate considerably more vitamin-rich fruits and vegetables than the others, and the Iowa group, who appeared to have larger total fruit and vegetable consumption than any of the others. The intake of the boys was significantly greater than that of the girls in practically all cases.

**Foods eaten by adults.**

The amounts of foods eaten by some 2189 women 30 to past 80 years of age in 5 North Central states were estimated from one-day recall records, and the amounts eaten by 274 California women

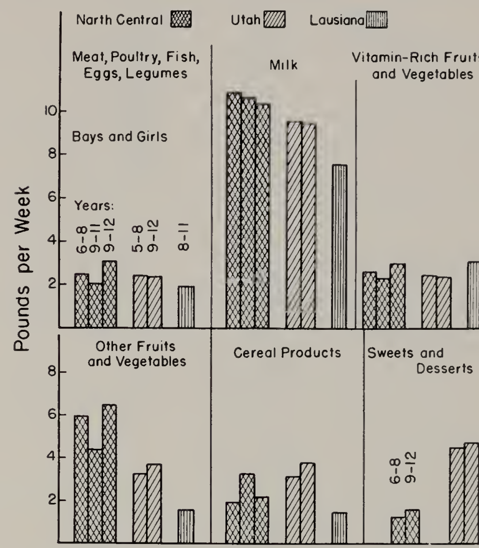



**Fig. 5. Consumption of six food groups in pounds per week by children 8 to 11 years of age in Louisiana, 9 to 11 in Iowa, Kansas and Ohio, and 6 to 8, 9 to 12 in Iowa, and 5 to 12 in Utah.**

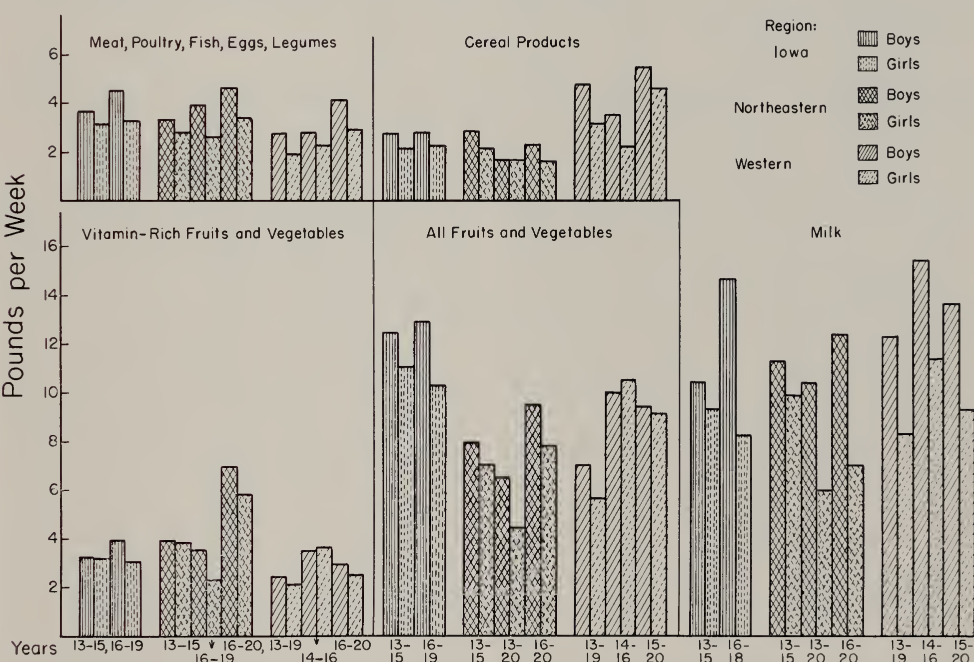



**Fig. 6. Consumption of five food groups in pounds per week by adolescents in four Northeastern states, Maine, New York, Rhode Island, and West Virginia; in Iowa; and in three Western states, Montana, Idaho and Utah.**

TABLE 4.—Consumption of Certain Foods by Adolescents in Three Western and Three Northeastern States.*

| State | Age and Sex | Meat, Poultry, Fish Eggs, Legumes | Milk | Cereal Foods | Potatoes | Other Fruits and Vegetables | Vitamin-Rich Fruits and Vegetables | Tomatoes and other Vegetables | Total Fruits and Vegetables |
|---|---|---|---|---|---|---|---|---|---|
| | | pounds per week | | | | | | | |
| Oregon | 14-16 yrs. | | | | | | | | |
| | 350 boys | 2.86 | 15.5 | 3.57 | 1.88 | 4.54 | 3.51 | | 9.93 |
| | 389 girls | 2.32 | 11.4 | 2.26 | 1.53 | 5.27 | 3.63 | | 10.43 |
| Montana | 15-20 yrs. | | | | | | | | |
| | 207 boys | 4.16 | 13.7 | 5.52 | 2.31 | 4.09 | 2.96 | | 9.36 |
| | 211 girls | 2.94 | 9.3 | 3.62 | 1.07 | 3.55 | 2.47 | | 7.09 |
| Idaho | 15-20 yrs. 274 boys and girls | 2.52 | 11.7 | 2.15 | 1.94 | 3.46 | 3.20 | | 8.60 |
| Maine | 13-15 yrs. | | | | | | | | |
| | 73 boys | 2.62 | 10.1 | 2.87 | 3.02 | | | 5.51 | 8.53 |
| | 72 girls | 2.26 | 7.8 | 2.32 | 2.60 | | | 4.50 | 7.10 |
| New York | 13-15 yrs. | | | | | | | | |
| | 114 boys | 3.83 | 12.1 | 2.80 | 4.70 | | | 2.96 | 7.66 |
| | 145 girls | 3.07 | 11.0 | 2.13 | 3.32 | | | 3.50 | 6.82 |
| West Virginia | 16-20 yrs. 47 boys | 4.67 | 12.4 | 2.30 | 2.48 | | | 6.95 | 9.43 |
| | 98 girls | | 3.42 | 7.0 | 1.67 | | | 5.80 | 7.87 |

*The method of classification of fruits and vegetables differed in the two regions.

50 to past 80 years of age from their 7-day diet records. In addition, similar 7-day records were made for 215 California men past 50 years old. Table 5 indicates the similarity of consumption of nine food groups by these adults. All quantities tend to decrease with increasing age, but the North Central and California groups had somewhat different patterns. The California women ate more meat and other protein foods, more milk, more sweets and desserts, less cereal and potatoes, less fat, slightly less fruits and vegetables (fig. 7). The California men, as well as the women, increased their milk intake with age but decreased slightly their consumption of the other foods. Data for the 77 New Jersey men are incomplete but indicate that they ate more milk and more cereal foods than did the older California men. Their potato intake was more than twice that of the California men (fig. 8).

The California subjects were for the most part city people of comfortable means, but the North Central women were from various types of communities. The Iowa and South Dakota women were chosen so as to represent statistically all the women over 30 years of age in their states. The Illinois women were residents of Urbana and the Michigan white women of the Lansing-East Lansing area, and these samples were so chosen as to be fairly representative of the white women of their age groups. However, the data

TABLE 5.—Summary of Average Amounts of Foods Consumed by Adults.

| Region | Sex and Age | Number of Dietaries | Meat, Poultry, Fish | Eggs, Cheese, Legumes | Milk | Cereal Products | Fats | White Potatoes | Vitamin-Rich Fruits and Vegetables | Other Fruits and Vegetables | Sweets and Desserts | Total Fruits and Vegetables |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | pounds per week | | | | | | | | | |
| | Female | | | | | | | | | | | |
| North Central | 30-39 | 441 | 1.71 | 0.74 | 3.07 | 2.16 | 0.93 | 2.25 | 3.92 | 2.00 | 1.52 | 8.17 |
| | 40-49 | 453 | 1.60 | 0.78 | 2.43 | 2.21 | 0.91 | 2.12 | 4.47 | 2.36 | 1.50 | 8.95 |
| | 50-59 | 406 | 1.63 | 0.74 | 2.10 | 2.04 | 0.84 | 1.98 | 4.39 | 2.34 | 1.49 | 8.71 |
| California | 50-59 | 95 | 1.80 | 0.80 | 2.86 | 1.62 | 0.47 | 0.71 | 4.05 | 3.07 | 2.09 | 7.83 |
| North Central | 60-69 | 271 | 1.32 | 0.72 | 2.24 | 2.22 | 0.87 | 1.97 | 4.40 | 2.43 | 1.31 | 8.80 |
| California | 60-69 | 106 | 1.78 | 0.81 | 3.56 | 1.69 | 0.59 | 0.76 | 4.21 | 2.90 | 1.95 | 7.87 |
| North Central | 70+ | 193 | 0.93 | 0.51 | 2.11 | 2.10 | 0.73 | 1.78 | 3.71 | 1.78 | 1.10 | 7.27 |
| California | 70+ | 73 | 1.48 | 0.72 | 3.99 | 1.60 | 0.45 | 0.67 | 3.53 | 2.71 | 1.75 | 6.91 |
| | Male | | | | | | | | | | | |
| New Jersey | 20-50 | 77 | | | 6.64 | 2.39 | | 2.75 | | | | |
| California | 50-59 | 79 | 2.75 | 0.84 | 4.67 | 2.41 | 0.76 | 1.20 | 4.09 | 3.54 | 3.13 | 8.83 |
| | 60-69 | 72 | 2.51 | 0.85 | 4.82 | 2.36 | 0.83 | 1.03 | 5.03 | 3.58 | 2.87 | 9.64 |
| | 70+ | 64 | 2.05 | 0.58 | 5.16 | 1.80 | 0.69 | 1.09 | 3.86 | 3.67 | 2.32 | 8.62 |

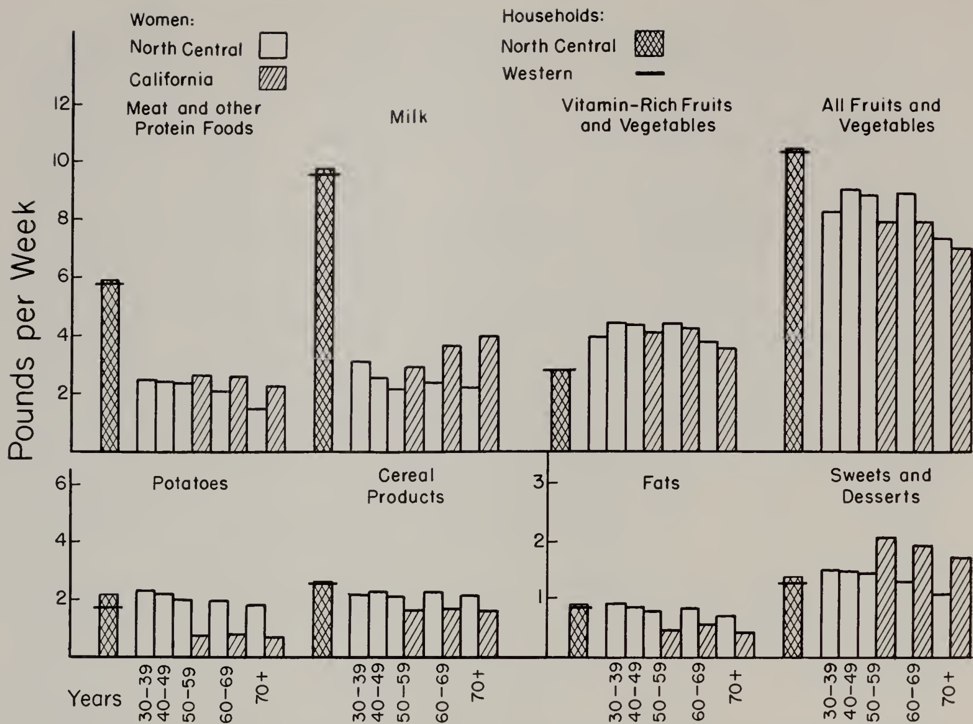



**Fig. 7. Amounts of foods in pounds per week eaten by adult women in North Central Region and California and the USDA family consumption values for the North Central and Western Regions.**

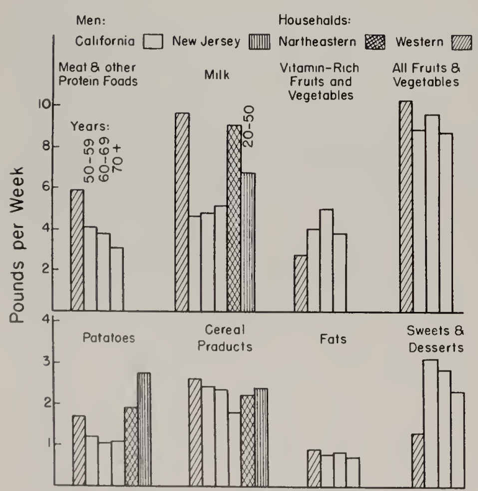



**Fig. 8. Amounts of foods in pounds per week eaten by adult men in California and New Jersey and the USDA family consumption values for the Western and Northeastern Regions.**

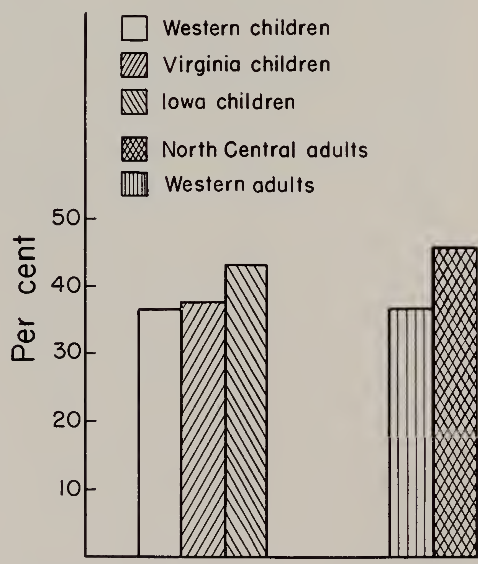



**Fig. 9. Percent of total food calories provided by fat in diets of children and adults in Virginia, North Central, and the Western Regions.**

obtained from the Minnesota women in St. Paul and the negro women in Lansing-East Lansing may be applied only to the individuals from whom they were obtained.

These figures may be compared with the average quantities of food brought into the house as reported in the USDA 1955 Survey. Most of the values in the household survey are larger than in the individual records. The amounts for meat, poultry, fish, eggs, legumes, and nuts in the survey total more than twice the amounts reported by these North Central and California women and men, and the milk consumption is three to four times as great. But only slightly greater amounts of cereal and potatoes were reported in the household survey. Consumption of vitamin-rich fruits and vegetables according to the individual records was about 50 per cent greater but of fats and sweets and desserts somewhat less than in the household survey. It may be that children and adolescents consume proportionately more milk, meat and other protein foods, about the same amount of potatoes and cereals, less vitamin-rich fruits and vegetables but more fats and desserts than the older adults.

### Calories from fat.

The North Central women seemed to eat definitely more fat than the California women (fig. 7). This is confirmed by the full record on fat eaten by both children and adults. The 1203 children and adolescents and the 705 adults studied in the West obtained 36.5 per cent (range, 35 to 39%) of their total calories from fat. In the North Central region, 41 per cent of the calorie intake of 2189 adult women was from fat, as was 43.5 per cent (range 42 to 47) of the intake by a group of 1188 Iowa children. Virginia children had 37.5 per cent of calories from fat. These differences are significant (fig. 9). In view of the grave attention now being given to the effect of both quality and quantity of dietary fat upon development of atherosclerosis and heart disease, these figures are impressive.

### The inherent nutrient content of foods compared with their calorie content.

The relationship of choice of food groups to the total nutrient value of the diet is illustrated in figure 10. From the 1-day diets reported by Iowa and South Dakota women, researchers calculated the percentage of the total food energy value of the diets that was provided by each of eight food groups: 1) meat, fish, and poultry; 2) milk; 3) bread and cereals; 4) vitamin-rich fruits and vegetables, that is, green and yellow fruits and vegetables, tomatoes, citrus fruits. and members of the cabage family; 5) white potatoes; 6) other fruits and vegetables; 7) fats; and 8) sweets and desserts. Similar calculations were made of the percentage of the total amounts of protein, calcium, iron and five vitamins in all the dietaries, provided by each of the same eight food groups. The percentage of total food energy furnished by each food group was then divided by the percentage of each of the nutrients each food group furnished. In figure 10, food groups that furnished higher percentages of the total amount of protein, for instance, than they

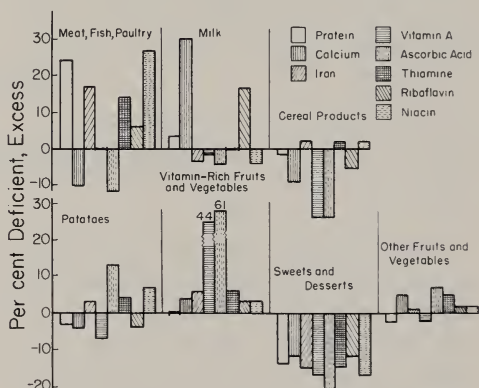



**Fig. 10. Percent excesses or deficits of nutrients in proportion to calories provided by certain groups of food.**

did of food energy are shown as having "excesses" of protein—that is, they were relatively more important sources of protein than of food energy in the diets reported by these women. A food group furnishing a lower percentage of the total value of a nutrient than of food energy is shown as having a "deficiency" in that nutrient—that is, it was less important as a source of that nutrient than as a source of energy in the diets studied. Sweets and desserts are thus shown as "deficient" in all the nutrients; cereals furnished slightly larger percentages of the total amounts of iron, thiamine, and niacin than of food energy, and much smaller percentages of calcium, vitamin A, and ascorbic acid than of food energy. Milk furnished much more calcium and riboflavin and slightly more protein in proportion to its calories, but less of the other nutrients.

Potatoes have about as many deficits as excesses; vitamin-rich fruits and vegetables have two large excesses, vitamins A and C, and no deficits; other fruits and vegetables have two small deficits, protein and vitamin A, and six small excesses. Clearly the calories of meat, fish, and poultry carry with them more than their share of protein, iron, thiamine, riboflavin, and niacin, but have a deficit of calcium and no ascorbic acid. Potatoes also carry a calcium deficit but supply ascorbic acid. If milk is included in the diet with meat, fruits and vegetables, the calcium deficit is handsomely wiped out and a bonus of riboflavin added. Meat, milk, and fruits and vegetables obviously form the solid framework of an adequate diet. Bread and other cereal foods have four large deficits and very small excesses, while sweets and desserts carry only deficits. Table fats, which supplied 21 per cent of the calories in the diets of these North Central women, provided only deficits of everything except vitamin A, which is found in butter, cream and margarine.

No serious calorie excess and nutrient deficit can arise when fruits and vegetables are eaten, even the maligned potato. With meat and milk, especially when taken in fair balance, the same is true except for ascorbic acid. Bread and other cereal foods do not similarly pay their way, and sweets and desserts pay nothing for their calorie ballast.

Although the values depicted in figure 10 were calculated from the dietaries of the Iowa and South Dakota women, these relative provisions of calories and nutrients by the food groups remain substantially the same wherever they are used and in practically all proportions, because they stem from the composition of the foods.

## SECTION 4

# The Nutrient Value of the Diets

Food is made up of individual chemical constituents which are broken away from each other in digestion and absorption and which enter the blood stream to be used by the tissues for the production of energy, secretions, hormones, blood, and tissues such as muscle, liver, kidney, nerves. The complete list of these *nutrients* may not yet be available, but they may be divided roughly into three groups: proteins and their amino acids; minerals, such as calcium, phosphorus, and iron; and vitamins. In addition, all the organic nutrients, that is, proteins, fats, and carbohydrates, are used as sources of calories or energy. Some distinction must be maintained between the indispensible nutrients such as certain amino acids, unsaturated fatty acids, the mineral elements, and the vitamins, which must be supplied intact, and the organic or fuel nutrients, proteins, fats, and carbohydrates, which may be substituted reasonably freely for one another as sources of calories. It is the balance between these indispensable nutrients and the total energy or calorie value of a food which governs the place of that food in the nutritionist's esteem. For example, pure sugar, sucrose, is a valuable calorie carrier but there its nutrient cargo ends. Lean meat is also a good calorie carrier but in addition it contains B vitamins, iron, and an especially well-selected assortment of amino acids in its protein. Turnip greens have little calorie value and little protein but a rich content of vitamins and minerals.

Altogether some 34 nutrients have been described as indispensable in food. This total includes water, 11 mineral elements, 12 vitamins, one or more fatty acids, and 9 amino acids and is definitely a minimum figure. Certain vitamin-like substances are still under investigation, and several trace elements are suspected of playing important roles in nutrition not yet defined. Of these nutrients, recommended daily requirements for growth, pregnancy, lactation, and adult life have been set up for only ten: calories, protein (to cover amino acid needs), calcium, iron, the three B vitamins, thiamine ($B_1$), riboflavin ($B_2$) and niacin, vitamin A, ascorbic acid (vitamin C), and vitamin D. The requirement for vitamin D is conditional and apparently applicable only under certain circumstances and during certain physiological periods.

**The recommended allowances of nutrients.**

These 10 nutrients were chosen for serious consideration by the Food and Nutrition Board of the National Research Council because more was known about them than about the others or because determining the need for them presents fewer uncertainties and stumbling blocks.

The remaining 23 nutrients are equally important, however, and deficits in them may be just as devastating in their consequences. The standard food composition tables do not yet contain reliable figures for such nutrients as vitamin $B_6$, pantothenic acid, folic acid, vitamin $B_{12}$, and several other necessary nutrients. In consequence, evaluation of diets for these constituents and even estimation of the human requirements for them are as yet incomplete. Our estimates of the nutritional values of the diets studied in the regional cooperative researches are incomplete and will remain so until these gaps are filled in. For example, there is reason to believe that vitamin $B_6$ (sometimes called pyridoxine) and pantothenic acid are just as vital to the enzyme mechanisms in our tissues as are thiamine, riboflavin, and niacin. But no estimates of human requirements have been officially recorded, nor is there any clamor for their restoration to white flour and bread as was the case with the latter three vitamins. The estimates of adequacy of the diets offered in these pages must therefore be taken with reservations, since deficits in these and other unrecorded nutirents may be as frequent and as serious as those recorded again and again for riboflavin, calcium, ascorbic acid, and vitamin A.

In any case a liberal estimate for the daily allowance for 10 nutrients for both sexes and various ages was set up in 1943 and revised in 1945, 1948, 1953, and 1958. These recommendations have attained wide circulation and perhaps have been too frequently regarded as "floors" in diet approval rather than as guides for diet planning. They are different from and considerably more generous than the similar so-called requirements set up as minimal by the Food and Drug Administration, the British Medical Association, and the Canadian Council of Nutrition. These latter standards provide either for physiological minima or literally for the average individual. The National Research Council recommendations provide a generous allowance which is expected to cover even the most unusual needs.

### Comparison of mean intake of nutrients with the allowances.

The extensive records of individual dietaries accumulated by the regional groups were in practically all cases subjected to much the same analysis. The data were punched on cards, machine sorted, and statistically evaluated. Most of the emphasis was placed not on individual foods but on the nutrients yielded by the total food intake. This allowed greater flexibility in interpreting the results but somewhat decreased the practical aspect of the food consumption records. The mean intake of the nine nutrients, including calorie or energy value, with range and standard deviations has been compiled for the age groups studied in the four regions. The tenth nutrient, vitamin D, was not included in these records because of the uncertainties as to the requirement in various climates, at various ages, and under various physiological conditions. Besides, when administered as a nutrient it is usually combined with milk, given in fish liver oil, or supplied as a vitamin addition to the diet.

### Distribution of the subjects.

The subjects were chiefly school children, especially high school children and college students in the Northeast, North Central, Southern, and Western regions, older women in the North Central, and older men and women in the West. A few other special groups were included, particularly male industrial workers in New Jersey, women industrial workers in Virginia, and pregnant women in Massachusetts. The nutrient intakes of the pregnant women were not included, however, in the average values quoted later.

There were in the age range 4 to 9 years, 164 children from three New York schools in small towns and rural communities, 288 in Iowa where 61 schools were sampled, 110 in Virginia in the Blacksburg district, and 78 in Ogden, Utah. There was little difference in nutrient intakes among these four state groups. In the 9- to 11-year group there were 1693 boys and girls in Iowa, Kansas, and Ohio; in the 8- to 11-year range, 487 children from five rural and urban areas in Louisiana; in the 10- to 12-year group, 101 in New York, 175 in Iowa, 109 in Virginia, and 50 in Utah. The adolescents, 13 to 15 years, were represented by 222 in New York, 208 in Maine, 59 in Rhode Island, 236 in Iowa, 59 in Utah, 128 in Colorado, 127 in Idaho, 221 in Montana, 202 in Washington. Of the 16- to 18-year group, 144 were in Iowa, 34 in Colorado, 147 in Idaho, 45 in Washington, and 34 in Utah, of the young people of college age, 16 to 20 years, 17 were in New York, 46 in Maine, 237 in Rhode Island, 232 in West Virginia, 197 in Montana.

There were 41 men and women in the age range 25 to 49 examined in Utah, 230 women in Virginia 20 to 50 years old, and 318 men in New Jersey in the same age range. In the North Central region there were 2438 women from 30 to past 80 years of age, and in California and Colorado 370 women from 50 to past 80 as well as 294 men in this age range.

The grand total was 5716 children and youths under 20 years of age and 3038 women and 632 men over 20 years of age. The boys and girls under 20 were about equal in numbers. The average values recorded for men over 20 to past 80 may be less reliable however because considerably fewer men than women were available in that age range. Figure 11 depicts the relative magnitudes of the populations whose dietaries were examined. The average age of groups were used in this figure; for example, for boys and girls aged 9 to 11 years the total is given as 10; 13 to 15 as 14; 16 to 20 as 18.

In figures 12 to 29 are presented the mean nutrient intakes for males and females separately and for age groups from 4 to over 80 years old. On each graph is also shown the recommended allowance of the nutrient for the age and sex of the group for which the average values are depicted. The results in all four regions are combined in these graphs. The recommended allowances used are those of the 1958 revision of the National Research Council Recommendations.

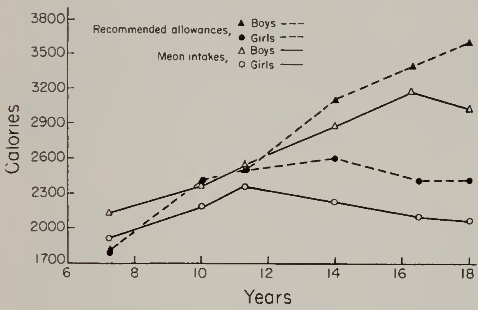



**Fig. 12. Average daily calorie intake of boys and girls from 4 to 20 years of age.**

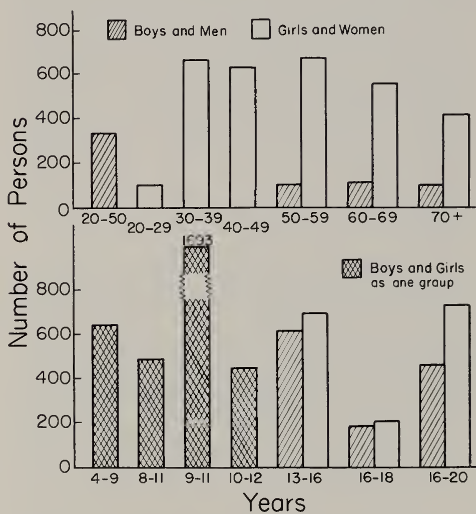



**Fig. 11. Number of persons whose dietary records were examined for nutrient intakes.**

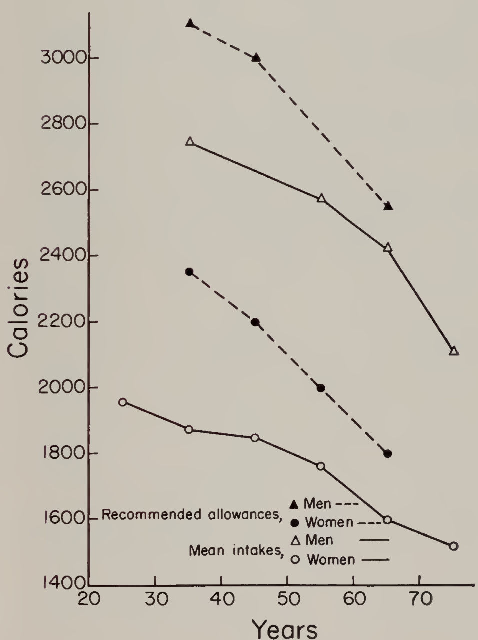



**Fig. 13. Average daily calorie intake of men and women from 20 to more than 80 years of age.**

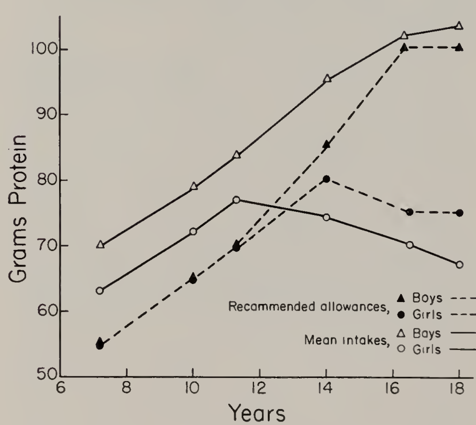



**Fig. 14. Average daily protein intake of boys and girls from 4 to 20 years or age.**

### Calories.

The figures showing average intake of calories or total food (figs. 12 and 13) indicate that either the calorie allowances for both children and adults are too large or the food records of these subjects consistently understate the amounts eaten. However, these separate dietaries for 5664 healthy children and 3670 adults should provide enough data to smooth out any irregularities in the averages. The calorie intakes agree quite satisfactorily with the allowances for children up to 12 years of age, but thereafter the intakes are lower for both boys and girls up to 20 years and men and women to over 70 years of age.

### Protein.

The protein intakes as shown in figures 14 and 15, on the other hand, are decidedly greater than the recommended quantity for boys and men at all ages. This is true for girls also up to age 12 or 13, but after that the average daily intake is significantly lower than recommended up to age 20. From 20 to 70 years of age the women's intake of protein was adequate, but it dropped significantly after age 70. Such a deficit in teen-age girls is particularly unfortunate.

### Percentage of calories yielded by the protein of the diet.

The percentage of calories yielded by dietary protein is considered by some physiologists and medical advisers to be a better indication of the protein sufficiency of the diet than the absolute amount of protein in grams or in grams per pound of body weight. In figure 16 is shown the percentage of calories from protein recommended by the National Research Council (1958 version) calculated from the amounts of calories and proteins, and the average percentage actually eaten by the children and youths observed in these cooperative studies of nutritional status. It is obvious that the dietaries recorded contained more protein in proportion to calories at every age than would be obtained from the amounts in the recommended allowances. The latter show about 11.0 per cent of calories from protein for boys and 12.4 for girls. But the average in the records was 13.2 per cent for boys and 13.0 per cent for girls. This difference is not chiefly due to the lower calorie intakes noted in figure 12 because the deficit in calories below the amounts recommended occurred only after the age of 13, but the percentage of protein calories remained practically unchanged throughout the observed age range, from 4 to 20 years.

A similar situation is seen in the records of intakes of adults. In figure 16 it is obvious that the actual percentage of calories from protein is practically constant for both men and women at all ages from 20 to past 70, 13.8 per cent for women and 13.6 per cent for men, as compared with rising values of 10.1 to 13.7 per cent rocommended for women and 9 to 12 per cent for men. The corresponding number of total calories in the recommended allowances falls steadily with age for both men and women, and the actual intakes likewise fall but always on a lower level. As with the children, the constancy of the percentage of calories from protein seems to indicate that the higher levels found in these dietaries are not merely the result of the lower total calories ingested. Moreover, the constancy of the figures at all ages, 13 to 14 per cent calories from protein for both sexes, suggests either a fixed pattern of dietary choice for the whole country or a response to some physiological stress, or both these conditions. Some nutritionists have recommended that 15 per cent of the calories be obtained from protein, particularly for adolescents and children. These widespread dietary studies seem to point to voluntary intakes of nearly this composition.

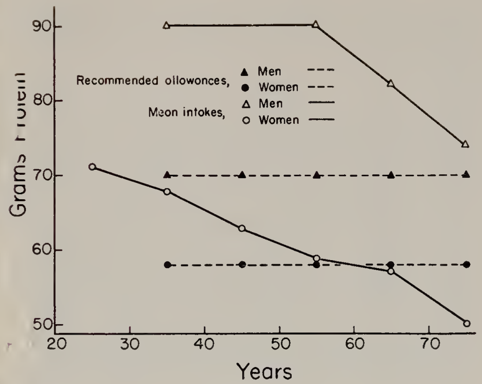



Fig. 15. Average daily protein intake of men
d women from 20 to more than 80 years of age.

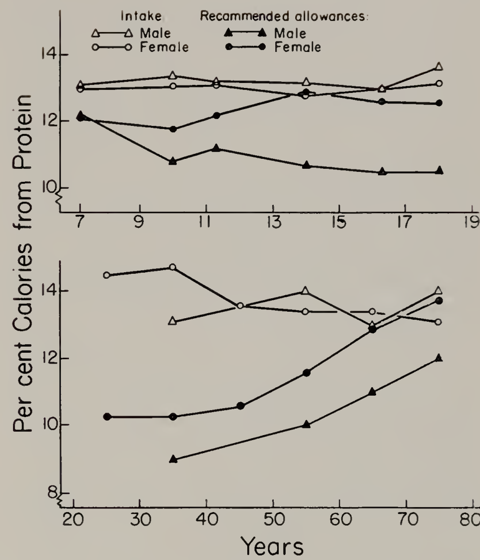



Fig. 16. Percentage of calories from protein in the diets of all the subjects.

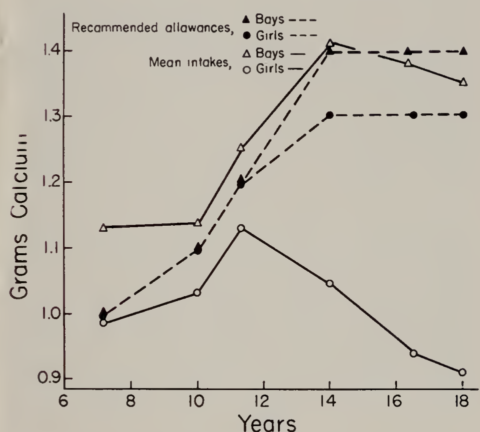



Fig. 17. Average daily calcium intake of boys and girls from 4 to 20 years of age.

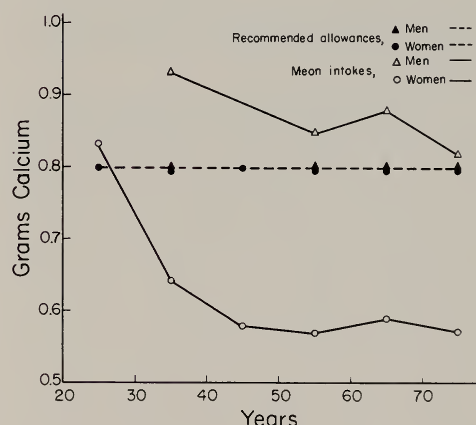



Fig. 18. Average daily calcium intake of men and women from 20 to more than 80 years of age.

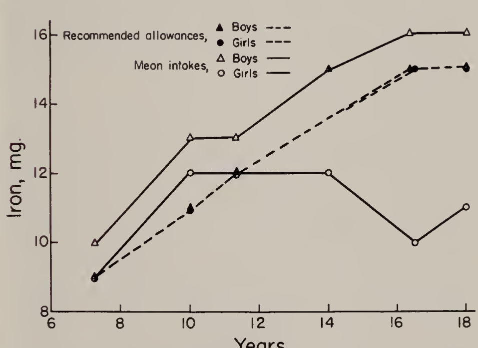



Fig. 19. Average daily iron intake of boys and girls from 4 to 20 years of age.

**Calcium.**

The calcium intakes, in figures 17 and 18, show a somewhat similar condition to that of the protein intakes. The boys' average daily calcium intake is at all ages up to 16 years about the same as the recommended amount, but that of the girls is clearly and increasingly low from 11 years of age on. For teen-age girls there is a very wide gap between the recommended allowance and the average intake of calcium. Almost the same conditions are true of diets of adult men and women. The women continue to diminish their calcium intakes into old age.

The question may well be raised as to the realtiy of this apparently alarming situation. No objective evidence of untoward effects from this condition upon health in girls and women was found in these or almost any other inquiries. There is, however, some indirect evidence sometimes cited as indicating damage due to low calcium intake. The number of young women who cannot, or at least do not, nurse their babies and the prevalance of dental caries, in boys as well as girls, have sometimes been ascribed to lack of dietary calcium. Proof of an actual relationship has not been seen, however, in either case.

It is possible that the estimated allowances for calcium are excessive because they are based chiefly on calcium balance or retention studies which are affected strikingly by the level of food calcium to which the subjects are accustomed. Some influential voices have been raised in recent years on this subject. If we dare assume that 5500 presumably healthy females cannot be wrong, the calcium allowance may be judged as too high. The dietary averages for girls show a maximum of 1.15 gm at 12 years of age, declining to 0.9 gm at 20 years and 0.5 gm at 70 years and beyond. The corresponding values for males are 1.3 gm at 12 years, 1.43 gm at 17 years, and 0.82 gm at 70 and beyond. These high intakes by the boys do not of course prove that their calcium requirements are similar higher.

**Iron.**

The iron requirement has also been the object of much experimentation and discussion for at least the last 90 years. Figures 19 and 20 indicate that the situation here is about the same as for calcium. The males meet or exceed the recommended amount at all ages, but the food intake of females from 12 years up to 30 shows a wide deficit. From 30 to nearly 60 years of age the requirement is exactly met by the women, but after 60 the deficit is established again. Much the same arguments used regarding calcium apply here. Iron absorption by the intestine appears, like that of calcium, to be somewhat self-regulating. Most of these minerals taken in with the food is excreted unabsorbed or is re-excreted into the intestine after absorption. When iron is not needed for blood formation, for example, no matter how much is ingested most or all of it is excreted from the bowel. It has been argued that women have greater blood losses than men in menstrual fluid and in childbearing and should therefore take larger amounts of food iron. But iron conservation appears to be extraordinarily efficient so that the lower intakes by the younger women are compensated by better absorption or less re-excretion. Hemoglobin, the iron-containing constituent of the blood, is also normally lower in girls and women than in boys and men, and, as well be shown later, this is regardless of iron intake.

**Vitamin A.**

The vitamin A in the foods, as mentioned earlier, is difficult to estimate accurately, partly because the forms in which it appears in animal and vegetable foods are different, and accurate measurement of the transformation of the vegetable or carotene forms into true vitamin A in the body is difficult. Some special laboratory studies on this subject are sketched in a later chapter In figures 21

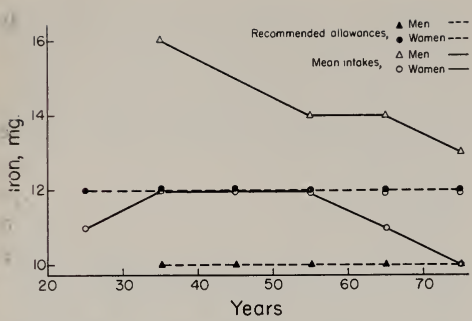



Fig. 20. Average daily iron intake of men and women from 20 to more than 80 years of age.

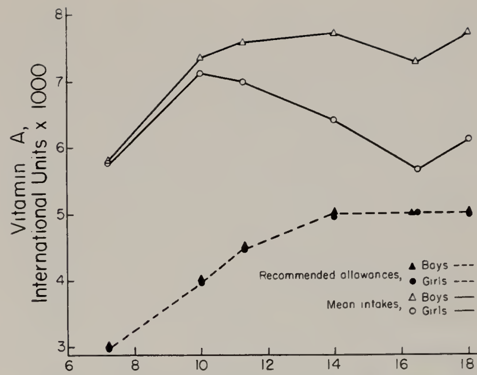



Fig. 21. Average daily vitamin A intake of boys and girls from 4 to 20 years of age.

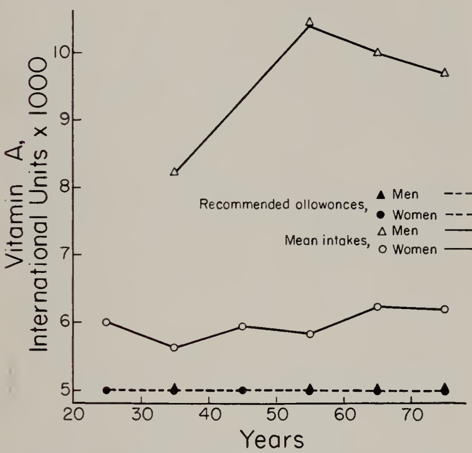



Fig. 22. Average daily vitamin A intake of men and women from 20 to more than 80 years of age.

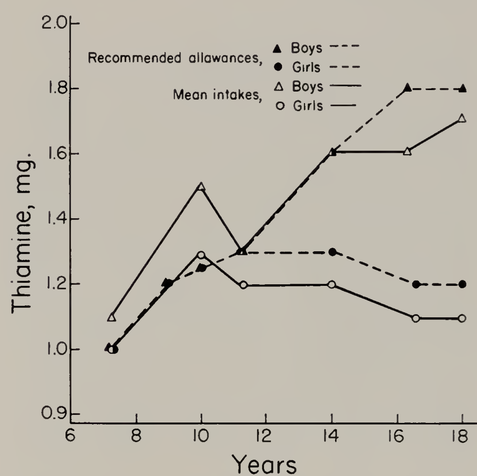



Fig. 23. Average daily thiamine intake of boys and girls from 4 to 20 years of age.

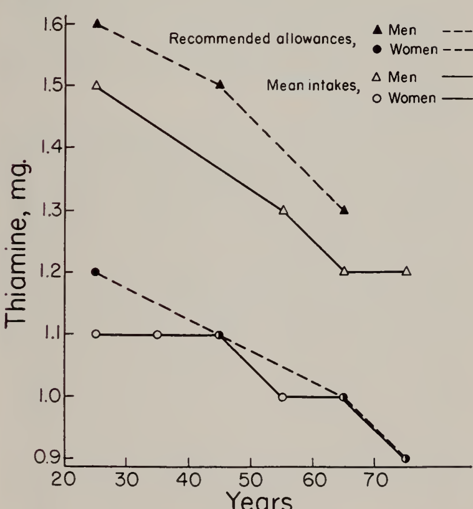



Fig. 24. Average daily thiamine intake of men and women from 20 to more than 80 years of age.

and 22 the average intakes are shown. Clearly these diets were on the average better than adequate in vitamin A if the recommended allowances of 3 to 5 thousand International Units per day be accepted. The males as usual had far larger intakes at all ages than the females, but the latter also always exceeded the allowances. By analogy we might suggest that the recommended quantities are somewhat low if the pattern of the modern American diet is followed. Since excess vitamin A is cumulative in the body, it appears unlikely that the majority of these subjects would at any time show stigmata of its deficiency.

**Thiamine and riboflavin.**

The thiamine and riboflavin intakes follow much the same pattern as the iron. In both cases the intakes of both boys and girls considerably exceed the allowances recommended up to age 11. After that the boys continue to have good intakes of thiamine up to age 14 but lower amounts than recommended thereafter. The girls have slightly low intakes of thiamine after age 12, but from 30 years on past 70 the intakes of the women are almost identical with the recommended amount (figs. 23 and 24). The consistently lower calorie intakes of these subjects may explain and justify these lower thiamine intakes.

In riboflavin the boys and men maintained much higher than required intakes at all ages. The girls after age 14 had less than the recommended amounts as did also the women except in the decades between 20 and 40 (figs. 25 and 26).

**Niacin.**

The need for niacin can, in part at least, be met by tryptophan, one of the amino acids supplied by food proteins. About 60 mg of tryptophan has been shown to yield about 1 mg of niacin. These diets were recalculated as to niacin equivalent value from this point of view with an assumed value of 1 per cent tryptophan for the dietary protein, and were found to be uniformly more than adequate. In fact, the niacin supplied as such in the diets was sufficient in most cases to meet the recommended amounts (figs. 27 and 28).

**Ascorbic acid.**

Ascorbic acid, vitamin C, has often been cited as the most vulnerable of all food nutrients because of its easy destruction by cooking, storage, canning, and even freezing processes. It is also found almost exclusively in foods of vegetable origin. Diets which are often found to be adequate in all other aspects may fail in providing this vitamin. Moreover, the tables of food composition tend to overrate the vitamin C content of foods as eaten, since cooking and processing losses are not always adequately represented. This variability has already been referred to in the chapter on dietary methods.

The ascorbic acid in the diets of children up to nearly 12 years was well in excess of the recommended amounts, but thereafter the deficit was steady up to 20 years in both sexes. After 30 years the intake of men was adequtae but that of women marginal or low (figs. 29 and 30). The meaning of these deficits, which are probably real, will be discussed later. It is also possible that for older men at least the recommended allowances are somewhat low.

To summarize, in every nutrient except calcium the diets of these 1600 girls as compared with the National Research Council recommended allowances were more than adequate up to age 12, and those of the 2800 boys were adequate up to age 20, except for ascorbic acid and total calories. The additional 1600 girls observed between 12 and 20 had large deficits in calcium and iron and smaller ones in ascorbic acid, thiamine, riboflavin, protein, and calories. Only in niacin and vitamin A were the girls' diets satisfactory throughout the growing years. There is some question as to the validity of these


Fig. 25. Average daily riboflavin intake of boys and girls from 4 to 20 years of age.

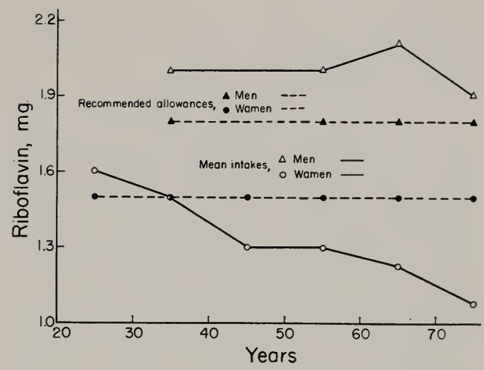



Fig. 26. Average daily riboflavin intake of men and women from 20 to more than 80 years of age.

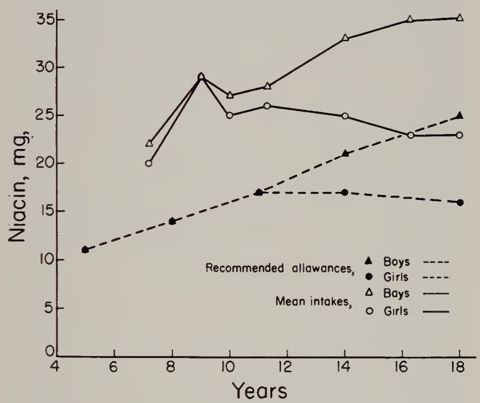



Fig. 27. Average daily niacin intake of boys and girls from 4 to 20 years of age.

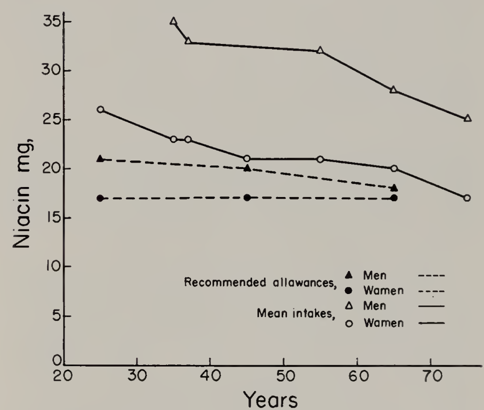



Fig. 28. Average daily niacin intake of men and women from 20 to more than 80 years of age.

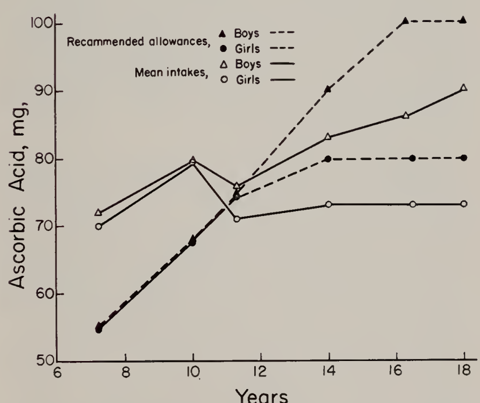



Fig. 29. Average daily ascorbic acid intake of boys and girls from 4 to 20 years of age.

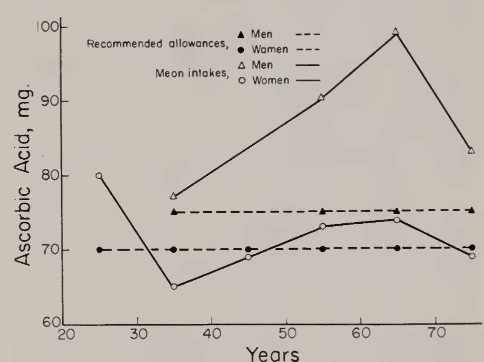



Fig. 30. Average daily ascorbic acid intake of men and women from 2 0to more than 80 years of age.

estimates of deficits since they are viewed against the perhaps artificial profile of the recommended allowances.

It is interesting to speculate on the reasons for the universally evident decrease in intake of some or most of the nutrients by girls after age 12. A greatly increased rate of growth normally occurs in boys and girls just preceding the onset of puberty, and this is followed by a rather rapid slowing down, particularly in girls. In boys the accelerated growth phase begins a year or two later than in girls and continues for several years longer. At least the deceleration following the adolescent spurt of growth is less marked. It is understandable, therefore, that food intake of healthy girls should be increased at ages 11 to 13 and decreased thereafter. The continued low intakes beyond age 13, however, particularly in calcium and iron, may be unfavorable and in part at least ascribable to poor food habits acquired during the decelerated growth period after puberty.

Men (1047 of them) from the age of 20 through the eighties used fewer calories and thiamine than were recommended but had excellent intakes of all the other nutrients measured. Women in these age groups (2674) had relatively low intakes of calcium and calories and slightly low riboflavin. Throughout, the women maintained adequate niacin, thiamin, and vitamin A and nearly adequate iron and ascorbic acid.

### Comparison of mean nutrient intakes among the regions.

**Children under 13 years of age.** The New York children had the best intakes of calcium, riboflavin, thiamine, niacin, and iron and adequate intakes of the other nutrients. The intakes of the North Central children excelled in vitamin A and ascorbic acid but were low in calcium, riboflavin, and niacin, and adequate in the other nutrients. The Southern children had low intakes of vitamin A and riboflavin but were generally adequate in the other nutrients. The Utah children also had low intakes of vitamin A and ascorbic acid, and the Utah girls' intakes of calories, protein, iron, niacin, and thiamine were notably low but those of the boys were adequate.

**Adolescents, 13 to 20 years old.** The adolescent boys and girls in the West had lower ascorbic acid, vitamin A, and calorie intakes than those in the other two regions, North Central and Northeastern. In addition, the Western girls had the lowest intakes of all the other nutrients except calcium and riboflavin. However, the Western boys had highest intakes of protein and niacin. The Northeastern groups of this age range had the highest intakes of calcium, iron, and thiamine and were lowest in none. The Iowa children had relatively high intakes of vitamin A, ascorbic acid, and calories but were low in niacin, riboflavin, calcium, and iron. The larger consumption of vitamin-rich fruits and vegetables and meat in the Northeast may account for the good intakes of nutrients, and the lower consumption of these foods in the West, counterbalanced by increased use of milk and cereal foods, may indicate the reason for the poorer showing of the Western children on nutrient intakes, especially of the girls whose diets were low in all nutrients, whereas the boys had good intakes of protein, niacin, riboflavin and calcium. The low intakes of riboflavin and calcium by the Iowa boys and girls, except for the 16- to 18-year-old boys, is reflected from their low milk consumption (Section 3, fig. 6).

**Adults.** The most important factor governing the intakes of the adults appeared to be age. The New Jersey men, 20 to 50 years old, had relatively high intakes of all nutrients except vitamin A and ascorbic acid. The same was true of the Virginia women in the same age range. The California and Colorado men, 50 to more than 80 years old, had medium to high intakes of all nutrients as did the women of this group except for iron, thiamine and niacin.

A fair comparison of nutrient intake can be made only between the North Central and the Western women, aged 50 to past 80 years, and between the former and the Virginia women, 20 to 50 years old. Calorie, protein, iron, and thiamine intakes are quite remarkably alike, decade for decade, among these three groups. In vitamin A, riboflavin, and ascorbic acid the Western women had significantly greater amounts than those of the North Central region and Virginia. The relatively young Virginia women had the highest calcium intake, the North Central women the lowest. The Virginia women also had a definitely higher intake of niacin than the others.

The superior intakes of riboflavin, calcium, and vitamin A of the Western women may in part be accounted for by their consistently greater milk consumption already noted (fig. 7). The higher

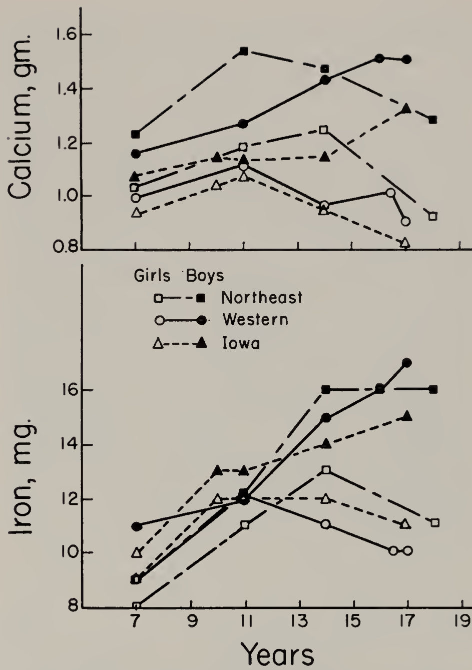



Fig. 32. Average calcium and iron intakes by children and adolescents in the Northeatsern and Western Regions, and in Iowa.

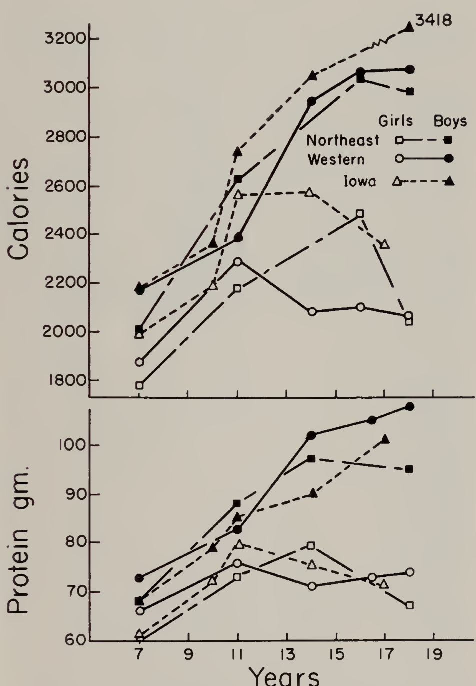



Fig. 31. Average calorie and protein intakes by children and adolescents in the Northeastern and Western Regions, and in Iowa.

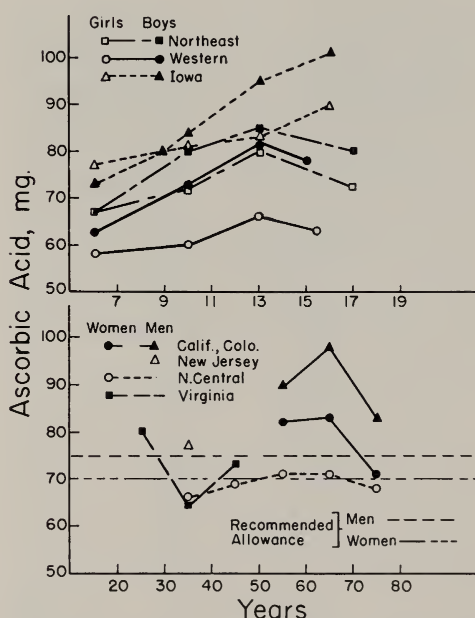



Fig. 33. Average ascorbic acid intakes by children and adolescents in Northeastern and Western Regions, and in Iowa; and of adults in Northeastern, North Central, and Western Regions.

intake of thiamine by the North Central women may be due to their greater use of potatoes and cereal foods. There is little to account for the difference in ascorbic acid intake, however, since the Western women ate slightly less vitamin-rich fruits and vegetables than did those in the North Central states. The wide variation in the occurrence of this vitamin in different foods of vegetable origin may well account for the difference if, as was apparently the case, the Western women chose more of the better endowed vegetables such as broccoli, cress, green peppers, turnip or mustard greens instead of cabbage, cauliflower, tomatoes, peas or green beans.

Figure 31 depicts the average intakes of calories and protein by the children and adolescents in the Northeastern and the Western regions and in Iowa. There are obviously few real differences as to protein, but the calorie intakes of the girls show considerable variation. In figure 32 is shown a similar comparison of calcium and iron mean intakes. The iron intakes appear to be fairly similar, but there are differences in the calcium values, particularly in the low intakes of the Iowa boys. The ascorbic acid intakes for both children and adults are shown in figure 33. Low values for the Western boys and girls and relatively high values for Western adults characterize this figure.

## SECTION 5

# How Many Had Less Than the Recommended Allowances of the Nutrients?

The average amounts of the nutrients taken by the many subjects of these dietary studies seem on the whole to be fairly satisfactory. But there were, of course, many persons with intakes which were well below these averages. The percentages of children, adolescents, and adults who had less than two-thirds of the recommended amounts were reported in several of the regions. Perhaps these figures indicate better than the averages the true story of good or poor food habits.

### Children under 13 years of age.

The percentages of 1710 children 5 to 12 years of age who ate less than two-thirds of the recommended amounts for their age of eight nutrients are shown in figure 34. In all these comparisons the 1953 version of the Recommended Allowances was used. The columns in figure 34 represent states in all four regions. The number of children with diets deficient in protein is obviously small. More were deficient in calcium, 7 to 20 per cent in all regions and 3 to 13 per cent in iron, most in New York and Virginia. Vitamin A-low diets were few except in Virginia and Louisiana and thiamine- and riboflavin-low diets were also few, less than 8 per cent in all states. Niacin was moderately low in New York, West Virginia, and Virginia diets, but ascorbic acid was present in less than two-thirds the recommended amount in 12 to 42 per cent of diets in all regions, Utah, Virginia, West Virginia, and Louisiana most markedly. These figures seem to indicate that a considerable number of children under 12 were eating too little citrus fruits, berries, tomatoes, melons, raw cabbage, and other vitamin C-rich fruits and vegetables. In the two Southern states the intake of vitamin A-rich fruits and vegetables, such as peaches, apricots, greens, and carrots, was also low. The high percentage of low niacin and iron intakes in New York may point to low meat intake and the moderate amount of calcium-low diets in all regions to somewhat low milk intakes.

In a few cases there are food-intake records to confirm these surmises. Utah children ate about 2.5 pounds per week of vitamin-rich fruits and vegetables compared with 4.5 pounds eaten by Iowa children. The ascorbic acid-low intakes in figure 34 reflect this. The Louisiana report on the number of servings of various foods eaten by 1222 children under 12 shows somewhat low average intakes of citrus fruits, green and yellow vegetables, butter and margarine, and eggs. All of these foods contribute vitamin A and the vegetables and eggs also contribute iron, both of which appear low in the Louisiana diets. The Virginia children were 175 white children, both town and rural, aged 8 to 11 years. Of these children the percentage receiving less than two-thirds the recommended allowances of riboflavin, ascorbic acid, protein, and vitamin A was greater than was found in any of the other five states which reported studies of children under 13 years of age. As will be seen later, the weights and physical condition of the children reflected these relatively low intakes.

Studies of large groups of boys and girls 9 to 11 years of age in Iowa, Kansas, and Ohio showed that the proportions of those who received less than two-thirds of the allowances varied among these states. In figure 35 it is shown that generally there were more deficits among the Kansas than the Iowa or Ohio children. This is true of iron and thiamine for the boys, riboflavin, niacin, ascorbic acid, protein, and calcium for both boys and girls. The Iowa and Ohio children had approximately the same percentage of deficit in all the nutrients except vitamin A and ascorbic acid, of which more Ohio children had low intakes. The Kansas children, especialy the boys, ate less milk, fruits and vegetables, and fats than the Iowa and Ohio children. However, it is not always easy to assess the cause of the low nutrient intakes from the food pattern. The vitamin and mineral con-

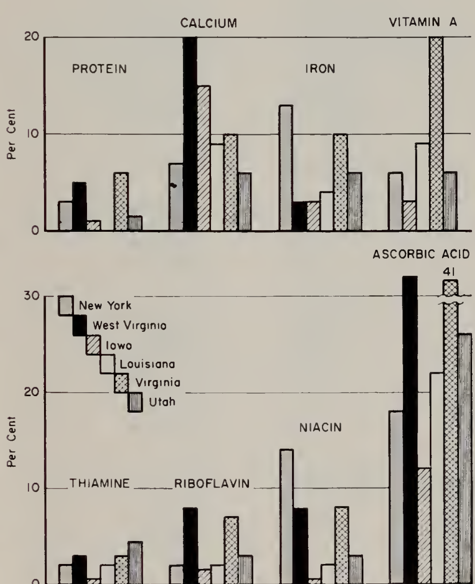



Fig. 34. Percentage of children under 13 years of age from six states who ate less than two-thirds the recommended allowance of mentioned nutrients.

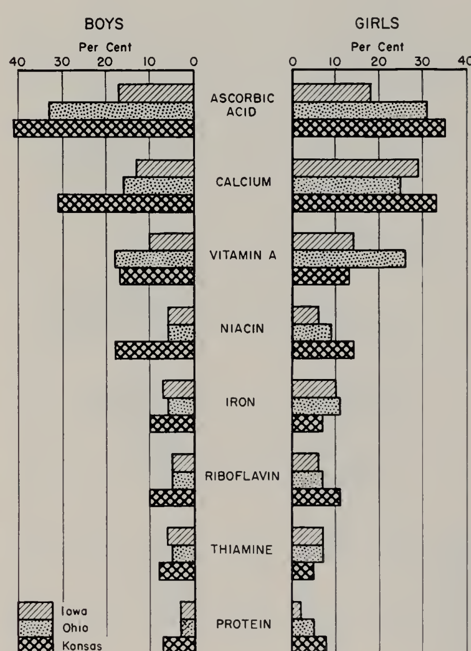



Fig. 35. Percentage of children 9 to 11 years of age in Iowa, Kansas, and Ohio who ate less than two-thirds the recommended allowance of mentioned nutrients.

tents of the various fruits and vegetables vary over such a wide range that generous intakes of these foods in one case may make poor nutrient provision, and in another, adequate or rich provision. Lettuce, celery, onions, radishes, apples, pears, even bananas and pineapple, carry relatively small amounts of both vitamins A (carotene) and C, as compared with tomatoes, peaches, apricots, yellow melons, strawberries, citrus fruits, carrots, spinach and most other greens. Cabbage and potatoes are notable chiefly because they are often used in generous amounts and significant contributions of ascorbic acid therefore obtained from them.

As will be shown later, these lower nutrient intakes by the Kansas children were associated with lower blood hemoglobin, serum ascorbic acid, and serum carotene but not lower serum vitamin A than were seen in the Ohio and Iowa children. These blood values are correlated with the lower protein and ascorbic acid intakes of Kansas boys and girls, low iron in the boys but relatively normal vitamin A intakes. On the other hand, the Ohio children shown to have low vitamin A intakes had also the lowest level of blood vitamin A.

### The adolescents.

In two Northeastern and six Western states many more adolescents (13 to 16 years old) than younger children reported less than two-thirds of the recommended allowance of one or more nutrients. In practically all cases the girls had far more dietary deficiencies than the boys. This was especially marked in calcium, iron, thiamine, riboflavin, and vitamin A. In a comparison of New York and Maine with Idaho, Montana, and Washington groups the percentage of boys with low intake records was about the same in both regions, but for girls the percentage was

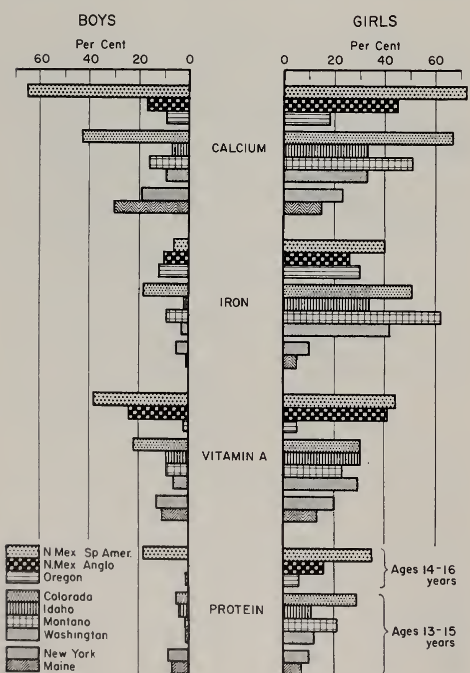



Fig. 36. Percentage of boys and girls 13 to 16 years of age in six Western and two Northeastern states who ate less than two-thirds the recommended amounts of mentioned nutrients.

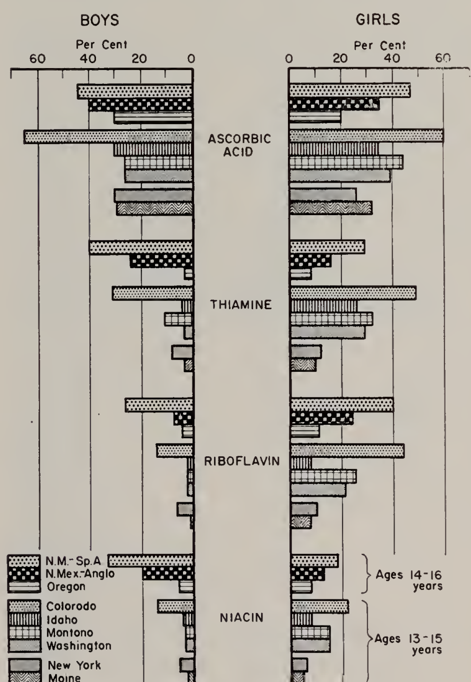



Fig. 37. Percentage of boys and girls 13 to 16 years of age in six Western and two Northeastern states who ate less than two-thirds the recommended amounts of mentioned nutrients.

smaller in the Northeast. (figs. 36 and 37.) Among the Oregon children 14 to 16 years old, few had less than two-thirds the recommended amounts of protein, vitamin A, thiamine, riboflavin, or niacin, but 20 to 30 per cent had less than that amount of ascorbic acid and iron, and 8 to 26 per cent were equally low in calcium. In all cases except that of ascorbic acid there were more girls than boys in the deficit column.

More Spanish-American New Mexico children had low intakes of every nutrient than did the Anglo-New Mexico or Oregon subjects of the same age range. Nearly half the Spanish-American girls had low intakes of most of the nutrients, and nearly half the boys had low intakes of vitamin A, ascorbic acid, thiamin, and niacin. Sixty-five to 75 per cent of the diets of both boys and girls were low in calcium. The Anglo-New Mexico children had less deficits in every case than the Spanish Americans but, except for protein and niacin in the case of the boys, more than the Oregon children. As will be seen later, these differences in intakes were accompanied by differences in growth rate, in physical signs of possible deficiency, and in blood composition.

In figure 38 are shown the corresponding percentages of Iowa children 12 to 18 years old whose intakes of the eight nutrients were less than two-thirds the amounts recommended. These deficits are not large except for calcium, iron, and ascorbic acid. Again, more girls than boys had low intakes, and there were more in the 15- to 18-year than in the 12- to 14-year groups.

Young people of college age, 16 to 20 years, in Rhode Island, West Virginia, and Idaho also often had low nutrient intakes (fig. 39). The boys had no iron deficit, but many of the girls had low iron intakes. The other deficiencies were generally similar and not excessive except for ascorbic acid and calcium. A startlingly large proportion of the young women in Rhode Island had diets deficient in thiamine. The girls' diets showed more deficits in iron and riboflavin than did those of the boys, but in all other nutrients the deficits were equally frequent in the diets of both girls and boys.

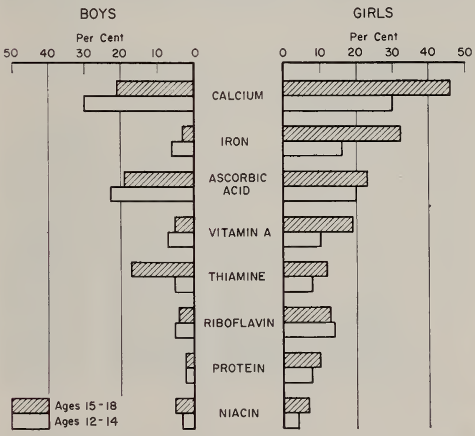



**Fig. 38. Percentage of Iowa children 12 to 18 years of age who ate less than two-thirds the recommended amounts of mentioned nutrients.**

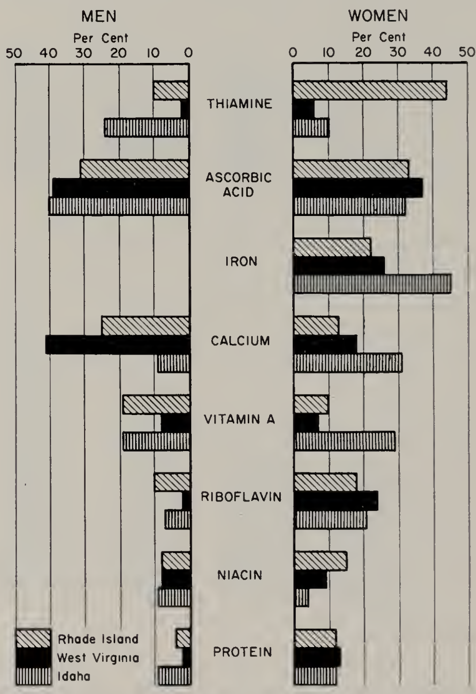



**Fig. 39. Percentage of men and women 16 to 20 years of age in Rhode Island, West Virginia, and Idaho who ate less than two-thirds the recommended amounts of mentioned nutrients.**

It seems that the girls past 16 years of age improved their eating habits slightly, but an equal number of boys retrogressed from the good status achieved up to age 16.

### Adults.

As shown in figure 40, many women from 30 years to past 80 took less than the recommended amounts of the nutrients. Of the women in six North Central states, nearly three-fourths had less than two-thirds the recommended amount of calcium, about half were similarly low in vitamin A, 20 to 30 per cent also were low in niacin, and 30 to 40 per cent in ascorbic acid and riboflavin. In nearly all cases the percentage of deficiency increased with age. Women past 50 years of age were also studied in California and Colorado and were found to have somewhat similar but less severe deficits. No consistent age change was observed in the intakes of the Western women. A group of women industrial workers in Virginia, 20 to 50 years old, was also included in this comparison. The percentage of the Virginia women in the deficiency column was much lower than those of the older North Central and Western women except for iron, vitamin A, and ascorbic acid. The number of women past 70 with low protein, iron, vitamin A, and ascorbic acid intakes is especially worthy of note.

In figure 41 are shown the corresponding data for New Jersey men 20 to 50 years old, a few Utah men 25 to 49, and California and Colorado men past 50 years old. In nearly all cases the Colorado men had more deficits than the California men of similar age. This was especially striking in calcium, vitamin A, and ascorbic acid. The protein, iron, and niacin intakes were generally fair in all cases. The New Jersey and Utah men had

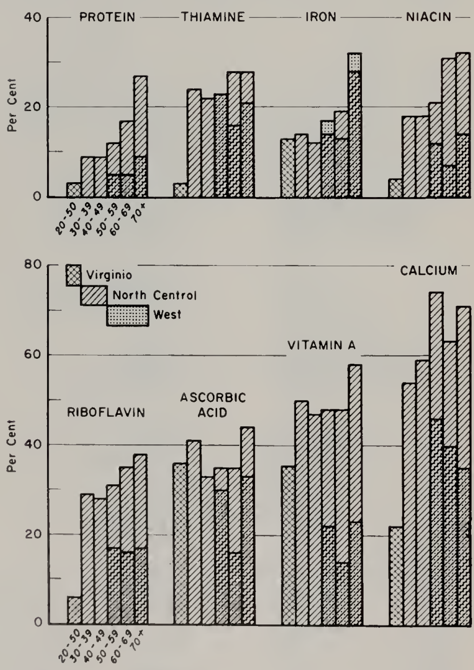



**Fig. 40. Percentage of women 20 to 50 years of age in Virginia, 30 to past 80 years of age in six North Central states, and 50 to past 80 in two Western states who ate less than two-thirds the recommended amounts of mentioned nutrients.**

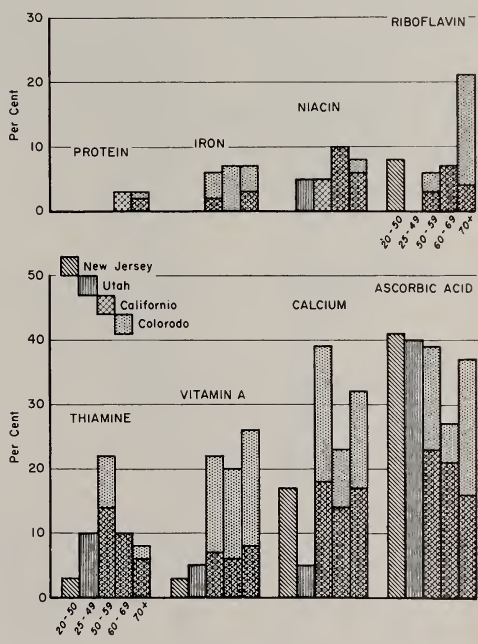



**Fig. 41. Percentage of men 20 to 50 years of age in New Jersey, and 50 to past 80 in California and Colorado who ate less than two-thirds the recommended amounts of mentioned nutrients.**

smaller percentages of deficit than the older groups in California and Colorado except for calcium and ascorbic acid. The men's records compare favorably with those of the women of similar ages except for ascorbic acid in which 20 to 40 per cent of both sexes were deficient.

**The Utah Study.**

An interesting comparison was made in Ogden, Utah, between the nutritional status of 131 children who had recovered from rheumatic fever and that of 131 carefully chosen similar children who had not had rheumatic fever. Some of the control children were brothers and sisters of those who had a history of rheumatic fever, and 41 parents, 20 men and 21 women, 25 to 49 years old, were also included in the group examined.

Ascorbic acid, calcium, and iron were the nutrients most frequently low in the children's diets, and ascorbic acid was most often low for both boys and girls. The older girls, 13 to 17 years old, frequently lacked enough iron and calcium. This was ascribed to their low intakes of milk and eggs. The younger children, under 10 had more relatively good diets (fig. 42), those 10 to 12 years old had diets of intermediate value and the oldest group, 13 to 19 years old had the poorest intakes.

The girls in the control group ate more calories, protein, fat, iron, thiamine, and niacin than those who had had rheumatic fever, and these control girls likewise had better hemoglobin and red blood cell counts than the rheumatic fever group. Intake of other nutrients and the levels of other blood constituents, except for sedimentation rates, were not significantly different in the two groups.

A statistical calculation of the influence of sex, age, nutrient intake, and rheumatic fever history revealed that age had the greatest influence on hemoglobin, red blood cell count, serum ascorbic acid, and serum carotene, but sex influenced serum

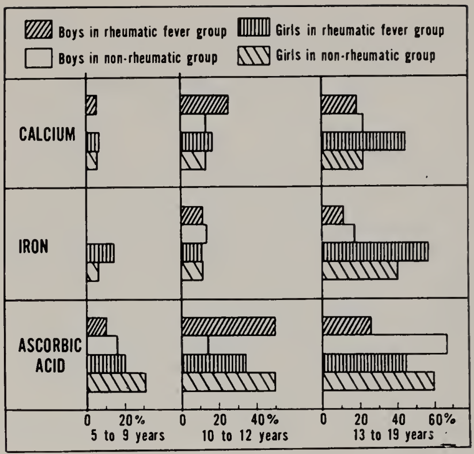



**Fig. 42. Percentage of children in Utah study who ate less than two-thirds the recommended amounts of mentioned nutrients.**

cholesterol and blood riboflavin, and rheumatic fever influenced the sedimentation rate. The sedimentation rate was higher in the girls who had had rheumatic fever than in the controls.

All the children had equally poor teeth. The 14- to 16-year-olds, for example, had an average of 11.5 decayed, missing, or filled teeth, exclusive of X-ray findings.

Slightly more of the children in the rheumatic fever group were underweight and classified as showing borderline or poor physique and growth. More of the boys with good physique and growth met the daily allowances for all nutrients except ascorbic acid than did those with poor growth. This distinction was not seen in the girls.

It is imposible to judge from these findings how much bearing, if any, diet habits may have had upon the incidence of the fever. Changes in diet undoubtedly occurred when the children were taken to the clinic, and some of these changes may have persisted. Changes in physical activity no doubt accompanied the convalescence from the disease. But some, although slight, effects upon blood composition and physique remained in the group which had had rheumatic fever.

SECTION 6

# The Blood Composition and Its Relation to the Diets

The blood composition is known to reflect the nutriture of the body, especially in the amount of hemoglobin, number of red cells, and concentration of ascorbic acid, vitamin A, and carotene. The amount of circulating alkaline phosphatase, an enzyme, is thought to be indicative of bone metabolism. Blood riboflavin may show the adequacy of intake of that vitamin, and serum cholesterol levels may have some diagnostic value, especially as to atherosclerotic danger. In most of the regional studies, only hemoglobin, serum ascorbic acid, vitamin A, and carotene were determined. The chief interest in making these analyses was the detection of variations from the currently accepted norms and correlation with the known

**Top left and right: North Central Region youngsters have blood samples taken for hemoglobin measurements. Lower left and right: Taking blood samples and getting vitamin A readings in the Northeastern Region.**

dietary intakes of the corresponding nutrients.

In the Northeast, hemoglobin, ascorbic acid, vitamin A, and carotene were determined on most of the subjects studied. A few drops of blood taken from the fingertip were sufficient for these tests, since approved microchemical methods were available. Referee blood samples were prepared and six of the Northeastern stations collaborated on a test of the accuracy and reproducibility of the methods. They concluded that day-to-day and hour-to-hour variability in the blood composition of the subjects was as great as the laboratory-to-laboratory variability and that neither the instruments nor the length of storage of the samples had a significant effect upon the results. Thus, in the Northeast at least, the blood values obtained at the six cooperating stations, Maine, Massachusetts, New York, New Jersey, Rhode Island and West Virginia, are comparable.

The age range in New York was from 4 to 20 years, but the number of subjects in the 16-to-20-year group was too small for reliability. In Maine the subjects were adolescents 13 to 15 years and college students 16 to 20; in Rhode Island the same age groups and a smaller group of women over 20 years of age; in West Virginia large groups of college students 16 to 20 years old and of both men and women over 20 years. Men 20 to 50 years old in New Jersey and pregnant women in Massachusetts were the other subjects.

In the North Central region much the same techniques as those adopted in the Northeast were used for both sampling and analysis. The subjects were chiefly school children, 9 to 11 years old, examined in Iowa, Kansas, and Ohio in connection with a study of the adequacy of the school lunches served in those states. In addition, a large sample of Iowa children 6 to 18 years of age was studied, including finger blood analysis as well as elaborate physical measurements and dietary records.

In Virginia and Louisiana 8- to 11-year-old children were examined as to blood composition and heights and weights recorded. Women 20 to 50 years old in Virginia were also subjects of this type of study. Blood samples were also analyzed in eight Western states. The subjects were adolescents 13 to 17 years old in seven Western states; in California and Colorado men and women over 50 years of age were studied, and in Utah children and adolescents from 5 to 19 and adults 25 to 49 years old.

#### Hemoglobin.

Up to the age of 12 there appeared to be no significant differences between the New York boys and girls in regard to hemoglobin content of the blood. A slow rise in the level is evident in both sexes up to that age, but thereafter the level for the boys continued to rise and that for the girls slowly declined (fig. 43). The groups 13 to 15 and 16 to 20 years old in Maine, Rhode Island, and West Virginia also showed higher values for the boys in all cases with increases in the levels in the older group, but no such increase occurred in the girls (fig. 44). By the usual standard of comparison (less than 11.0 to 13.0 gram-per cent hemoglobin according to age and sex) more of the Maine and Rhode Island subjects, especially the girls, were close to anemia than were the New York or West Virginia subjects.

Statistical study of the blood values for about 1500 subjects in the Northeast revealed several valid correlations with related dietary constituents. Hemoglobin was found to be corelated significantly with both dietary protein and dietary iron in five of the six cooperating states. The sixth state, New Jersey, examined only male industrial workers 20 to 50 years of age. Here there appeared to be a negative correlation with iron, none with protein. However, the iron and dietary intakes of these men as well as their hemoglobin levels, mean level 15.3 per cent, were all high, and the correlation may therefore not represent a true nutritional relationship.

In Virginia, town and rural whites and negroes were examined, and in Louisiana white children from five parishes, two in cities and three in farming areas. All were 8 to 11 years old. The sample was

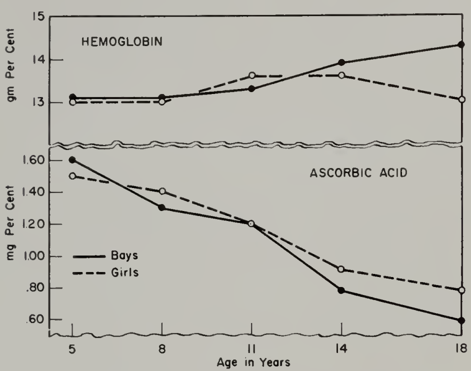



Fig. 43. Hemoglobin and ascorbic acid levels of blood of New York children.

chosen to represent these areas statistically. The Virginia town subjects, both white and negro, had higher hemoglobin values than their rural counterparts in both the 8- to 9- and 10- to 11-year-old groups. The Louisiana children had values similar to those of the Virginia town children and the New York children of the same ages (fig. 45). Only 4 per cent of the Louisiana children were classified as in poor condition so far as hemoglobin goes, as compared with 15 per cent of the Virginia children. In Virginia a positive correlation was found between dietary protein and hemoglobin levels but no such relationship between dietary iron and hemoglobin. In Louisiana a highly significant positive correlation was detected between dietary iron and hemoglobin levels but no significant correlation with dietary protein. The Louisiana children had diets considerably richer in protein than did the Virginia children and

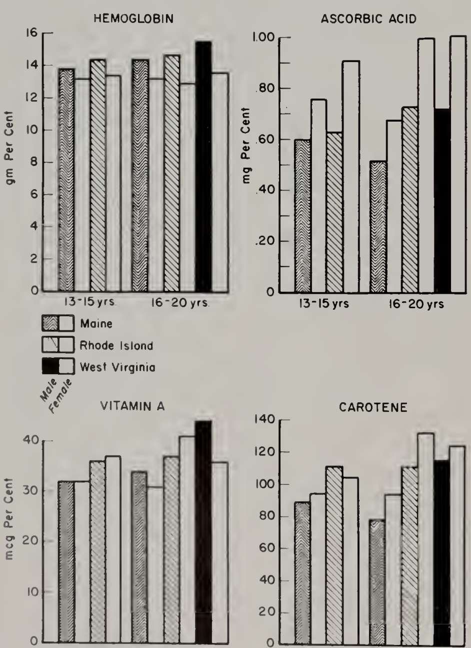



Fig. 44. Hemoglobin, ascorbic acid, vitamin A, and carotene levels of blood of Maine, Rhode Island, and West Virginia adolescents.

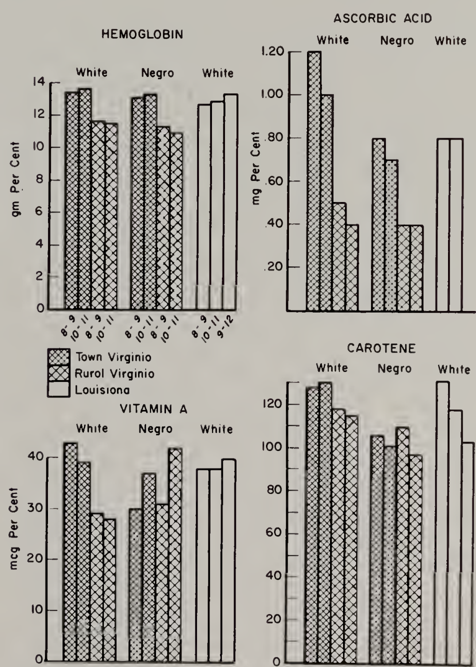



Fig. 45. Hemoglobin, ascorbic acid, vitamin A, and carotene levels of blood of Virginia white and negro children 8 to 11 years of age, and Louisiana white children 8 to 12 years of age.

fewer of them had low protein intakes, but the iron of the diets was about the same in the two states. Possibly the generally higher levels of hemoglobin shown by the Louisiana children as compared with those of the Virginia group, which were weighted by the low values for the negro children, and the higher protein intakes may explain the difference in correlations.

The hemoglobin curves for Iowa children 6 to 18 years old were similar to those of the New York and Western children. The rural children had generally lower values than the town children (fig. 46) with the usual maintenance or drop shown by the girls after age 12. This corresponds with the well-established drop in both nutrient intake and growth which occurs in girls at this age. Only 3 and 5 per cent of the Iowa girls and boys showed hemoglobin values which might be considered consonant with anemia. The boys' hemoglobin values were significantly correlated with their protein, niacin, iron, and riboflavin intakes, but this was not established for the girls. Since all these nutrients are concerned with the blood-making processes, positive correlation is not surprising. Since both iron intakes and hemoglobin levels were irregular in the girls, the relationships may be obscured. Nevertheless, the mean protein intakes of these Iowa children, both boys and girls, follow closely their hemoglobin levels (fig. 46).

In the study of 9- to 11-year-old school children in Iowa, Kansas and Ohio it was found that the hemoglobin of the Kansas children was strikingly lower than that of the children of the other two states. At this age little difference can be seen between the hemoglobins of boys and girls (fig. 47). No attempt was made to correlate the hemoglobin findings with the diets in these three states, but it is evident from figure 35, that more Kansas children had low intakes of protein and, except for the Kansas girls, of iron as well than did those in Iowa and Ohio.

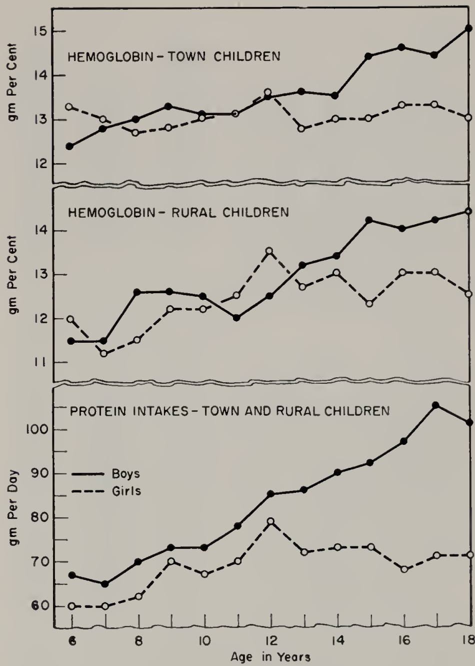



**Fig. 46. Hemoglobin level of blood of town and rural Iowa children, and their average daily protein intakes.**

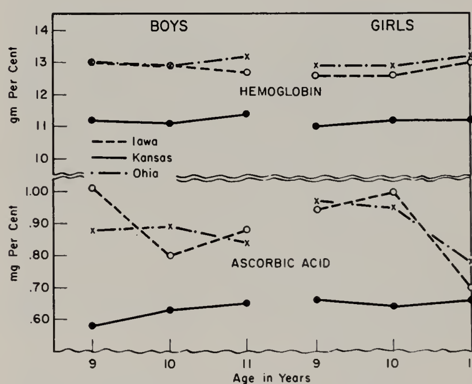



**Fig. 47. Hemoglobin and ascorbic acid levels of blood of Iowa, Kansas, and Ohio children 9 to 11 years of age.**

A comparison was made between the children in these states who customarily ate the lunch provided at the schools and those who did not. No consistent significant differences in hemoglobin values between these two groups could be discerned (fig. 48).

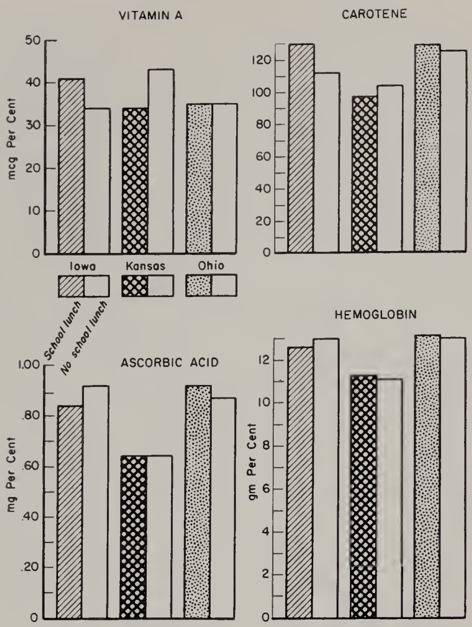



**Fig. 48. Hemoglobin, ascorbic acid, vitamin A and carotene levels of blood of Iowa, Kansas and Ohio children 9 to 11 years old, some customarily participating and others not participating in the school lunch offered.**

In the Western region, standard microchemical methods of analyzing fingertip blood were adopted, but in some cases full-scale tests on venous blood from the arm were chosen. The subjects were 70 children under 12 in Utah; 1299 boys and girls 13 to 16 years old in Arizona, Oregon, Montana, Idaho, Colorado, and Utah; 689 boys and girls 14 to 17 years old in Idaho, New Mexico and Washington; 197 college students 16 to 20 years old in Montana; 41 men and women 25 to 49 years old in Utah; and in California and Colorado 237 men and women 50 to 59 years old, 250 who were 60 to 69 years old, and 214 who were 70 years old and over. The numbers examined were large enough for statistical validity in all age groups except the youngest, under 12 years, and the middle group, 25 to 49 years. If these are included, however, a curve for blood composition for the whole life cycle may be constructed. The long interval between the ages of 18 and 55 can be represented by only one value, so the curve is questionable between these points. The children and adolescents had much the same values for hemoglobin as the New York children of similar ages. After age 12 the boys had rising values, with the maximum at age 18 of more than 15.2 per cent hemoglobin; the girls after age 14 showed no rise, with maximum at 13.8 per cent. Both these values are higher than in the New York groups (figs. 43 & 49).

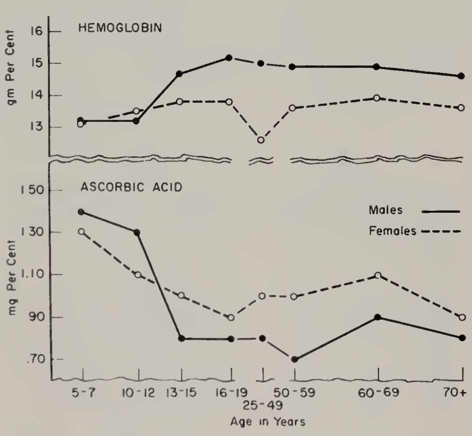



**Fig. 49. Hemoglobin and ascorbic acid levels of blood of children and adults in eight Western states.**

It is not surprising that the Western subjects should attain relatively high hemoglobin levels, since many of the communities in which the subjects lived are at relatively high altitudes. The Colorado, Montana, Utah, New Mexico, and part of the Oregon groups lived at altitudes of 4000 to 11,000 feet. Hemoglobin concentration is regularly increased in acclimated persons living at mountainous altitudes.

After 50 years of age the average hemoglobin for men descended slightly from the 15.2 peak for the group 16-19 years of age, to 14.6 beyond 69 years. The same is true of the curve for the women past 50 except that a peak of 13.9 is seen between 60 and 69 years. The single point for men 25 to 49 years old is in line with the values for younger and older ages, but that for the women is at a low of 12.6. Perhaps this is a reflection of blood loss during the reproductive period.

At the Nebraska station a special study was made not only of the hemoglobin but also of the serum iron of 275 healthy women 17 to 86 years old. The means for all the women were 116 micrograms per cent of iron and 13.2 gm. per cent of hemoglobin. The serum iron regularly decreased with age, but there was no accompanying decrease in the hemoglobin, nor was there any discernible relationship between the decrease in serum iron and the occurrence of the menopause. Although about 15 per cent of the women studied by the Nebraska group had less than two-thirds the recommended amount of food iron, low intakes cannot explain the decreasing iron levels. No explanation is at present available for this decrease with age.

The Montana adolescents showed a positive correlation of hemoglobin with iron intake and the New Mexico group with protein intake. The older men and women studied in California had significant correlations between hemoglobin and both dietary protein and iron. In general when intakes of protein and iron were generous the correlations with hemoglobin were less obvious.

**Ascorbic Acid.**

Serum ascorbic acid levels in the New York children aged 5 to 18 years showed a continuous downward curve from the youngest to the oldest ages. The girls at all ages beyond 6 years had higher levels, except at age 11 where the two sexes had the same value, 1.2 mg-per cent. At age 18 the boys had 0.6 mg-per cent and the girls 0.8. The latter values are generally regarded as barely adequate for vitamin C nutriture (fig 43). Almost exactly the same phenomenon was noted in the Western children except that the boys maintained a higher level than the girls up to age 12 (fig. 49). However, smaller numbers of these younger children were observed in the West than in New York. The serum ascorbic acid of 650 children from 6 to 14 years old was studied in Iowa (fig. 50). The girls had higher values up to 8 years but lower thereafter. At 12 to 14 years the levels were down to 0.7 and less than 0.6 mg-per cent for boys and girls, respectively. These latter are not reassuring values.

The adolescent boys studied in Maine, Rhode Island, and West Virginia had low to fair levels of serum ascorbic acid; the girls had fair to good levels. The West Virginia and Rhode Island older subjects, college students, had higher values for both boys and girls than the younger adolescents (fig. 44).

Nearly a third of all males over 13 years of age in the Northeast study had serum levels below 0.4 mg-per cent, a definitiely poor status. Another third of the males and half of the females had good status, that is, more than 1.0 mg-per cent levels.

The Virginia town white children 8 to 11 years old had satisfactory ascorbic acid levels, but the town negro and the Louisiana white children had barely adequate levels. The rural white and negro Virginia children had levels below adequacy (fig. 45). These levels parallel the similar but less severe conditions noted for hemoglobin. In all these cases fairly close correlations were found between

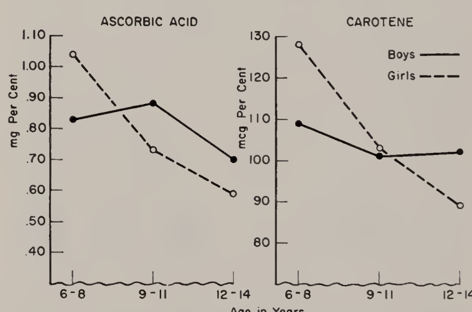



**Fig. 50. Ascorbic acid and carotene levels of blood of Iowa children 6 to 14 years of age.**

intake of ascorbic acid and its level in the serum.

The Kansas children 9 to 11 years old, as was the case with hemoglobin, had significantly lower ascorbic acid levels than did the Iowa and Ohio children (fig. 47). Again there was no consistent effect upon this blood constituent due to the consistent consumption of the school lunches (fig. 48).

The Western region showed also the drop from maximum values for serum ascorbic acid at 8 years to 18 years in both boys and girls. The boys had higher values up to 12 years after which the girls had somewhat higher levels. After 50 years the women had higher serum ascorbic acid than the men at every age (fig. 49). Both men and women showed a peak at 62 years after which there was a decline. The curves were fairly continuous with those in the earlier age groups, indicating a slow rise from 18 to 62 years in women and a drop from 18 to 50 years in the men with a rise to 62 years.

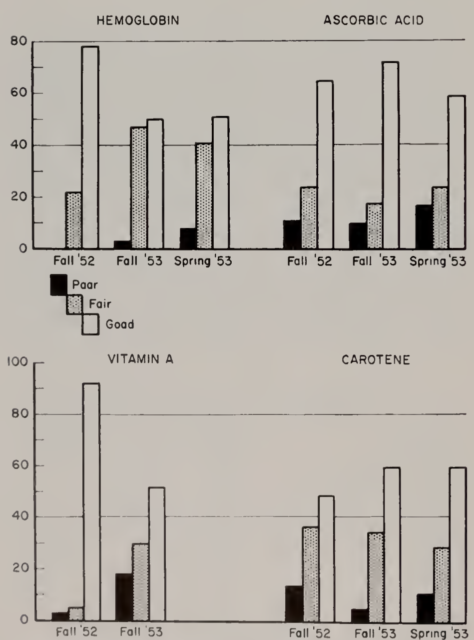



**Fig. 51. Percentage of Virginia women industrial workers, 20 to 50 years of age, who had poor, fair, or good blood levels of hemoglobin, ascorbic acid, vitamin A, and carotene.**

The serum ascorbic acid levels of the Virginia women 20 to 50 years were also mostly satisfactory even though some of the dietary intake records showed some instances of low intake (fig. 51). In general, however, the higher the ascorbic acid intake, the higher the serum level. Satisfactory serum levels of 0.7 and 0.8 mg-per cent were maintained on daily intakes of 49 mg or less, leading to a question as to the validity of the NRC recommendation of 70 mg for such maintenance. However, if the optimum or "saturated" serum level of ascorbic acid is taken as 1.0 mg-per cent or more, this was achieved in all tests only when the intake exceeded 130 mg per day.

Significant correlations between dietary ascorbic acid and these serum ascorbic acid levels were shown in the Montana, New Mexico, California, Utah, and Washington studies. Both the Southern surveys in Virginia and Louisiana showed the same relationship as did the Northeastern groups. In some cases the correlation was less convincing than in others. In general, the sharpest effects were noted when the intake of ascorbic acid fell to low levels.

### Vitamin A and carotene.

These vitamins are often estimated together in the diet, since quantities of both are expressed in International units. It is questionable, however, whether carotene should be given its full vitamin A equivalence because its physiological transformation to vitamin A is subject to variation and loss. Usually the circulating levels of vitamin A and carotene are of similar magnitudes, that is high levels of vitamin A often are present when the carotene levels are high. This is not always true, however, since the serum carotene reflects only the recent and current intake of the green and yellow vegetables and fruits, main sources of carotene, while the vitamin A level represents the physiologically active form of the vitamin, produced by intakes of both animal vitamin A from milk fat, fish oils, egg yolk, and liver and by transformation in the body from the carotene obtained from certain vegetables and fruits, egg yolk, and to some extent also from milk fat. A current or recent change in dietary carotene may raise or lower the level of that substance in the blood without effect upon the serum vitamin A. The latter is therefore the true criterion of vitamin A nutriture, the former only of current carotene intake.

In the New York studies (fig. 52) serum vitamin A was found to rise steeply in both boys and girls from 5 to 8 years of age, then decline to a minimum at 14 years with little change thereafter to 18 years. The girls generally had higher values than the boys. The carotene values, on the other hand, started high in the youngest children and declined gradually to the lowest point at 18 years of age. Again the girls had higher levels. These values were paralleled very closely for carotene by blood of the Western children (fig. 53), but serum vitamin A rose gradually from the youngest to the oldest groups except for the girls in the 16-19 year age bracket. The Western boys had higher values than the girls for vitamin A but about the same for carotene.

Of adolescents studied in Maine, Rhode Island, and West Virginia (fig. 44) the older boys and girls, 16 to 20 years, had generally higher blood values than the younger, 13 to 15 years. The Maine subjects had usually the lowest and the West Virginia students the highest serum vitamin A and carotene concentrations.

In Virginia and Louisiana the same pattern seen in hemoglobin and ascorbic acid emerged (fig. 45). The town white Virginia children and all the Louisiana children had satisfactory vitamin A levels, but the younger rural white and the younger town and rural negroes showed lower levels. The older children, 9 to 12 years old, except for the rural Virginia white children had satisfactory levels. The carotene values for the younger children were similar in trend to the vitamin A levels, but in the older children, town and rural Virginia negroes and the Louisiana children had lower levels. There was no direct parallelism between the vitamin A and carotene serum levels except for the best-fed groups, town white in Virginia and the Louisiana younger children.

In the examination of Iowa, Kansas, and Ohio children 9 to 11 years old the serum vitamin A of both boys and girls in Kansas was usually above the concentration found in the children of the other two states, but the carotene levels of the Kansas children were low (fig. 54). This illustrates again the difficulty of interpreting these vitamin concentrations. The

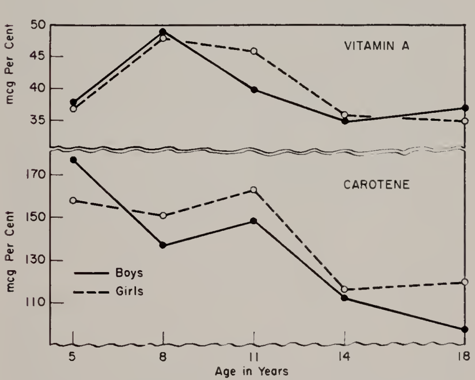



**Fig. 52. Vitamin A and carotene levels in blood of New York children.**

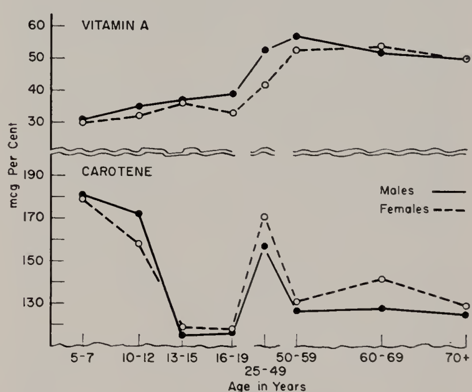



**Fig. 53. Vitamin A and carotene levels of blood of children and adults in eight Western states.**

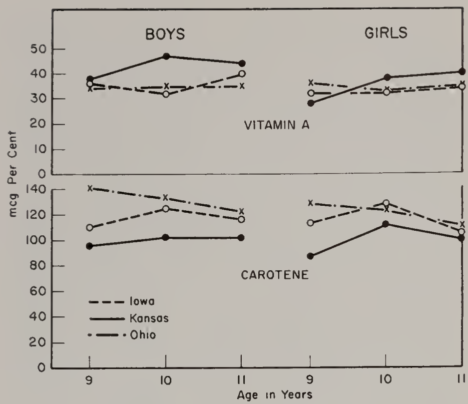



**Fig. 54. Vitamin A and carotene levels of blood of Iowa, Kansas, and Ohio children 9 to 11 years of age.**

long-time vitamin A status of the Kansas children was apparently good, but either their food contained more animal vitamin A and less carotene than that of the Iowa and Ohio children, or their current carotene intakes were lower than in former periods.

The family food-record studies referred to in Section 3 showed that in comparison with this, a smaller percentage of Kansas families and boys and girls had less than two-thirds the recommended allowance of vitamin A. The children's individual records of mean vitamin A intakes showed that Kansas boys had less vitamin A in their diets than either the Iowa or Ohio boys, and that the dietary vitamin A of the Kansas girls was intermediate between that of the Iowa and Ohio girls. The percentage of girls who had less than two-thirds the recommended allowance of vitamin A in Kansas was less than in the other two states, and the percentage of Kansas boys in this classification was about the same as the Ohio but more than the Iowa boys. The high blood vitamin A of the Kansas children is therefore not wholly accounted for.

As noted previously for hemoglobin and ascorbic acid, participation by these children in the school lunch had no consistent effects upon either vitamin A or carotene. The Iowa children who took the school lunch had higher blood vitamin A and carotene, but the opposite was true in Kansas and there was no significant difference shown by the Ohio groups (fig. 48). It may be that the school lunches offered were no more nutritious in these respects than the home diets of the children.

More than 90 per cent of the Virginia women industrial workers had good levels of serum vitamin A in the first test in the fall of 1952, but this dropped to 52 per cent in the following fall. In all these trials carotene levels were good in 50 to 60 per cent of the group and poor in only 10 to 14 per cent (fig. 51). In this study the total intake of vitamin A and carotene was found to vary directly with the serum levels of both vitamin A and carotene. The West Virginia men over 20 years of age and the New Jersey male industrial workers 20 to 50 years old had similar serum vitamin A and carotene levels, 47 to 49 mcg-per cent of vitamin A and 126 and 135 of carotene.

In the Western region the vitamin A curve of men and women showed a gradual rise between ages 18 and 50, from about 35 mcg-per cent at 18 to 55 at 55 years, with a gradual decline or maintenance thereafter (fig. 53). The serum carotene showed a much less exaggerated rise between these age groups, from about 118 to 128. If vitamin A excesses are permanently stored in the body against future needs, this rise in the blood values for older people might be expected. Much less, if any, accumulation with age might be anticipated for carotene, since this substance is storable usually only after transformation to vitamin A. These Western adults evidently had surplus intakes of vitamin A but only moderate intakes of carotene. This is borne out by the dietary records.

Positive correlations were found between vitamin A and carotene intakes and carotene blood levels in Montana, New Mexico, and Washington adolescents, California older men and women, and Virginia women 20 to 50 years old. No significant correlations between serum vitamin A and total vitamin A intake were found in the Northeastern surveys and in Washington and Idaho. However, no separation of dietary vitamin A and carotene was atempted in the Northeast. Whenever such separation was established, as in the Montana, Washington, and California studies, for instance, highly significant positive correlations between the dietary and the blood levels of carotene emerged. The correlation of blood vitamin A with dietary vitamin A or with combined vitamin A and carotene was less striking and in some cases even not significant.

In the Louisiana and Virginia studies of pre-adolescent children a positive correlation was found between total vitamin A intake and both blood vitamin A and blood carotene. Dietary carotene was not tested separately. Often enough these studies have revealed positive correlations between serum ascorbic acid, serum carotene and serum vitamin A. This may be due to the common distribution of carotene and ascorbic acid in fruits and vegetables or may of course represent a metabolic relationship between them. There is little evidence, however, for the latter possibility as yet.

### Alkaline phosphatase.

This enzyme is supposed to indicate the extent and normality of bone growth and maintenance. High values appear during infancy and adolescence, when rapid bone growth occurs, and also in connection with rickets and other bone disorders. Low values occur in scurvy, hypothyroid cases, and in weight loss. Supposedly both calcium and vitamin D utilization are indicated by these values.

Only New York and Maine in the Northeast, Iowa in the North Central, and Utah, Montana, and Idaho in the Western region made this determination. A sharp rise occurred in the New York girls at age 10 to 12 and in the boys at

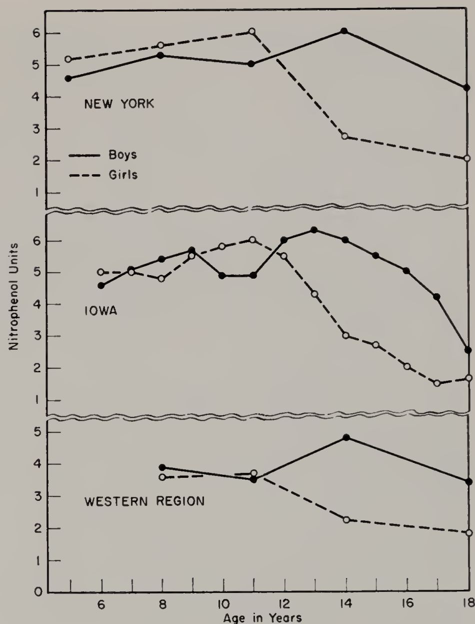



**Fig. 55. Alkaline phosphatase concentration in blood of New York, Iowa, and Western children.**

13 to 15. These years represent the peak of pubertal growth in the two sexes. The Iowa children showed the same peak ages (fig. 55) followed by gradual lowering to 2.5 and 1.5 by age 18. The latter are the usual adult levels, reached earlier by girls than by boys. It is interesting that between ages 7 and 8 and 12 to 13, when the Iowa girls showed a conspicuous slowing of growth in both heights and weights, the alkaline phosphatase levels dropped precipitously. The same is true of the boys; at ages 9 to 10 when the slowest rate of growth occurred there was the same drop in alkaline phosphatase. Rapid growth in girls at age 10 to 12 and in boys at 13 to 15 was accompanied by sharp rises in serum alkaline phosphatase.

Quite similar results were noted in the West (fig. 55). The girls at age 11 and the boys at age 14 showed maximal values as well as maximal growth rate. Rapid lowering to the adult level at age 18 occurred in girls but not in boys. In Montana an inverse relationship was

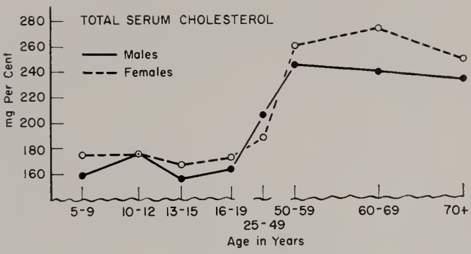



**Fig. 56. Total serum cholesterol levels of children and adults in seven Western states.**

shown between phosphatase levels and height within sex groups; the taller subjects generally had the lower phosphatase levels. There was also a trend toward higher phosphatase levels in the subjects with the lower calcium intakes. This is a valuable clue which should be followed up because easily determined indications of good or poor calcium nutriture are not at present available.

### Blood serum cholesterol.

Only in the West was blood serum cholesterol determined in nearly all subjects (fig. 56). At all ages the females had higher levels than the males except for the small groups of men and women in Utah between the ages of 25 and 49. In Utah a small group of subjects aged 5 to 12 years was also studied. The large number of adolescents from 13 to 20 years old studied in Idaho, Montana, Washington, Colorado, and New Mexico establishes fairly well norms of 167 mg-per cent for girls and 156 for boys at about age 14, and 172 and 163 mg-per cent at about age 18. The older women from age 50 on had much higher values, 260 at 55 to a peak of 273 at 65 and down to 262 at 70 and over. The men of those ages showed a steady decline from 245 at 55 years to 232 at age 70 and over.

These studies were among the first to establish the relative cholesterol levels in older men and women and revealed the need for separate norms for men and women of this blood constituent. The California study of the older group of men and women showed a positive correlation of blood cholesterol with both fat and cholesterol in the diet. Much interest has been shown in recent years in the concentration of circulating cholesterol, since there are suggestions that this may be an index of arteriosclerosis. The establishment of a normal range for age is therefore an important problem not yet fully solved. In a later chapter the experiments in this field carried on in the Northeast, North Central, and Western regions are reviewed.

## SECTION 7

# Growth of Children and Adolescents in Relation to Their Diets

It is well established that the growth of children may be affected by diet as well as by hereditary factors, hormones, illness, and other factors of environment. In some of these regional studies measurements were made of height, weight, build, developmental schedule, and other characteristics of the children whose diets were recorded.

In Iowa an elaborate set of measurements of about 1200 boys and girls 6 to 18 years of age was obtained in 61 schools. Less detailed but similar observations were made in Louisiana and Virginia on children 8 to 11 years old; in the joint study of school children 9 to 11 years old in Iowa, Kansas, and Ohio; and on smaller groups of children under

Of these 10-year-old Iowa girls, all but the one in the center were in the A4 channel of body build. The one in the center was in the A3 or medium channel.

These are 13-year-old Iowa girls. The one in the center was in the A3 or medium channel; the others are in the A4 or stocky channel of body build.

13 years of age in Utah and New York. Adolescents were studied in New Mexico, Washington, Idaho, Montana, New York, Maine, Rhode Island, and West Virginia. In all these studies an attempt was made to relate the diets of the children to their physical growth and development.

**The Iowa children.**

The average heights and weights of Iowa school children 6 to 18 years old are shown in figure 57. As it happened, earlier studies done in Iowa City to obtain standards regarding the growth of children and in Des Moines to standardize clothing sizes, provided excellent confirmation of the validity of these measurements and of the comparatively stable growth rates of Iowa children. A tendency toward an increase in weight in proportion to height showed itself, however, especially in teen-age girls. Between 10 and 13 years of age the girls' growth in both height and weight exceeded that of the boys. After age 14 this tendency was reversed.

The height-weight-age-sex measurements of these children were compared with the so-called standards set up by Baldwin and Wood in 1923 from examination of some 129,000 children of school age (5 to 19 years) from 12 schools in the Northeastern and North Central regions. Other so-called norms for school-age children, the Jackson-Kelly charts based on height and weight measurements of 24,500 Iowa children, were published in 1943 and the similar Stuart and Meredith tables, also based on studies of Iowa City children, were published in 1946.

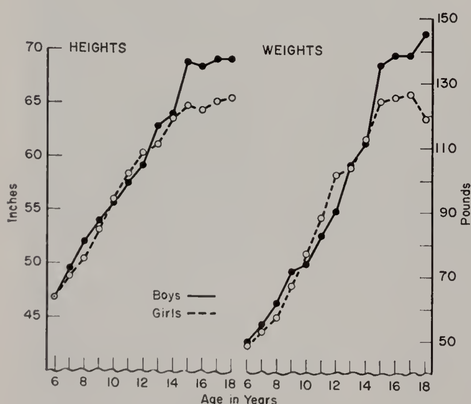



**Fig. 57. Mean heights and weights of Iowa children 6 to 18 years of age.**

Another standard of both growth and development is the Wetzel Grid, a chart set up in 1941 for measuring the progress of individual boys and girls over a period of years. These body build or physique classifications are based on mathematical formulae set up to interpret these data in terms of growth. The relationship of weight to height determines the physique channel of the child and this is further adjusted to age to indicate the channel of development or "auxodrome" in which the child is placed. The physique channels are Obese, Stocky, Medium, Thin, and Very Thin. The develovmental auxodromes indicate the probable type of growth, that is, Good, Doubtful, or Poor, by comparison with the records of 7000 normal children previously examined. Thus a child might have height and weight indicating stocky or medium physique but in comparison with the developmental standards, good, doubtful or poor development for age.

In figure 58 it can be seen that at all ages more Iowa girls than boys were of obese and stocky physique and that usually fewer girls were medium or thin. The tendency toward stockiness increased in


**Fig. 58. Percentage of Iowa children with various body builds.**

the girls from the younger to the older groups but was relatively constant in the boys. In figure 59 the schedule of development of the children in the pilot study is also shown, indicating that 65 to 75 per cent had both good physique and good growth. About 7 per cent of the boys and 11 per cent of the girls were obese; less than 5 per cent of the children had good physique but slow growth except for the 16- to 18-year-old group of whom 13 per cent had slow growth. At all ages more boys than girls had thin build but good growth. Only 5 to 7 per cent had thin build and poor growth; however, 12 per cent of the 9- to 12-year-old girls fell into this category.

**The Iowa, Kansas, and Ohio children, 9 to 11 years old.**

The comparison of Iowa, Kansas, and Ohio school children 9 to 11 years old is of interest also in reference to these measurements. In a preliminary survey of children 6 to 18 years old in one school in each of the three states, 62 to 64 per cent of all the boys were classified as of medium body build, while the Wetzel norm was 70 per cent. In Iowa 72 per cent of the girls were of medium build, in Kansas 55 per cent, and in Ohio only 43 per cent, against a standard of 57 per cent. There were no obese boys in Ohio and less than 5 per cent in Iowa and Kansas. However, in all three states there was an excess of obese girls, 11 to 12 per cent as against the norm of 8 per cent. There were more stocky Iowa

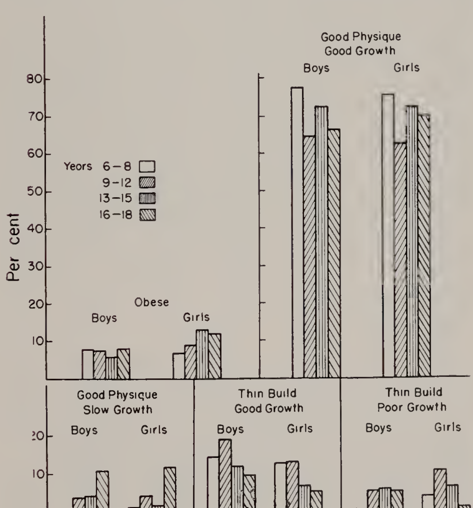



Fig. 59. Schedule of development of Iowa children.

A well fed, healthy, Iowa girl.

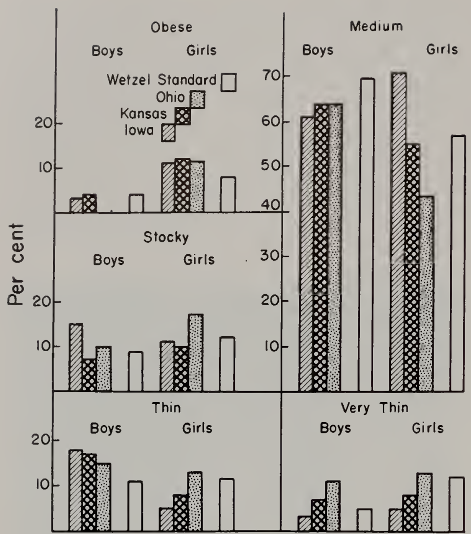



**Fig. 60. Percentage of Iowa, Kansas, and Ohio children 9 to 11 years of age with various body builds, compared with the Wetzel standard of occurrence of these builds.**

boys and Ohio girls than the Wetzel standard called for, more thin boys at every age in all three states and fewer thin girls except for Ohio, more very thin boys in Kansas and Ohio, and fewer very thin girls in Iowa and Kansas than the so-called standard. The Ohio girls and the Iowa boys showed the greatest variation from the standards (fig. 60).

The rate of development pictured in figure 61 shows again that nearly 50 per

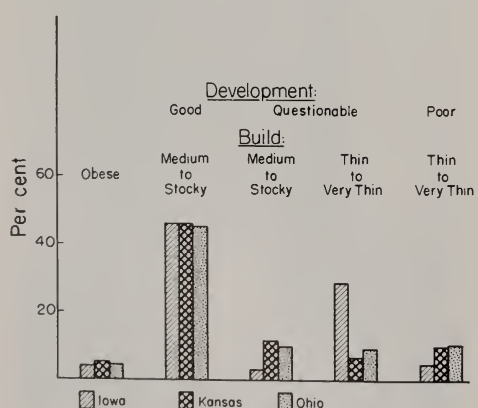



**Fig. 61. Schedule of development of Iowa, Kansas, and Ohio children 9 to 11 years of age.**

cent of the children in all three states were of medium to stocky build with good rate of development; 15 to 18 per cent of the Kansas and Ohio children, but only 5 per cent of the Iowa children, were of this build but questionable development. Many more Iowa children, however, were thin to very thin and showed questionable development, but relatively few of this body build showed poor development. In general, it was concluded that the growth of the majority of the 397 boys and girls was satisfactory, although more of the boys were thin or very thin and more of the girls obese than in the standard Wetzel distribution.

### Weight-height-age-sex comparison with the Baldwin-Wood standards, children under 13 years.

The under- or overweight attained by children was frequently compared with so-called standards or norms obtained by statistical treatment of measurements of large numbers of children. The Baldwin-Wood survey was most often used for these comparisons.

In the Virginia study (fig. 62) of white and negro town and rural children 8 to 11 years old, the following percentages were determined: those more than 10 per cent underweight for height and age, those within 10 per cent of normal, and those more than 10 per cent overweight. The same comparison was made for the 487 white children of the same age in Louisiana. The white children in the two states had almost the same distribution, 23 per cent under- and 14 per cent overweight. Of the negro children 40 per cent were underweight and 12 per cent overweight.

By this criterion the Iowa, Kansas, and Ohio children of nearly the same ages (9 to 11 years) had about the same distribution of under- and overweight as the Southern white children. In Iowa there were fewer in both the under- and overweight class, however, than in the other states (fig. 62).

Utah boys and girls 5 to 12 years old may be compared with New York children of the same age group. The New York boys and girls obviously had fewer underweight and more overweight members than the Utah group.

### The Northeastern measurements: adolescents.

Similar comparisons of children of high school and college age were made in Maine, New York, Rhode Island, and West Virginia (fig. 63). In Maine the boys and girls 13 to 15 years old had a normal distribution of under- and overweight with more of each among the girls, but 54 and 60 per cent in the normal category. In West Virginia nearly 30 per cent of the boys and nearly 60 per cent of the girls were underweight. This latter is an extraordinary figure for girls of this age. In the Northeastern region New York had the fewest boys who were underweight and the most who were overweight. The New York and Rhode Island girls were of like distribution with about one-third more than 10 per cent overweight. In the smaller groups of college age, 16 to 20 years, in Maine underweight was more common than overweight, in Rhode Island these were well balanced, but in West Virginia the number of girls who were underweight and of boys who were overweight was unusual.

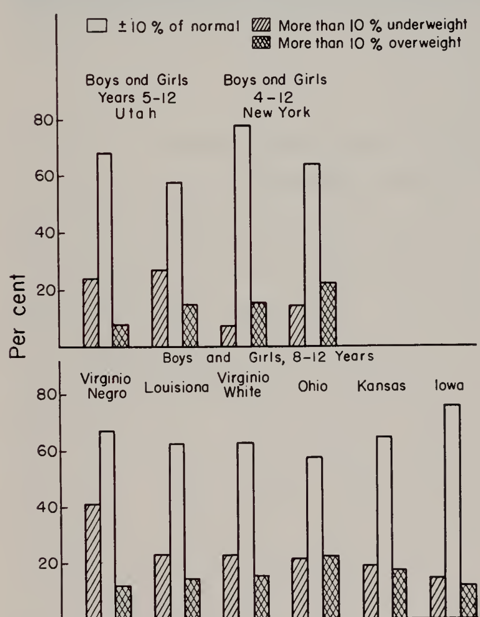



Fig. 62. Percentage of children under 13 years of age in seven states who were significantly underweight or overweight for their age, height, and sex.

### The Western measurements: adolescents.

Adolescents in large numbers were studied in New Mexico, Montana, Idaho, and Washington and a special group of Papago Indian children in Arizona. In figure 64 the average heights and weights of these groups are illustrated along with those of the Iowa children of the same ages. The New Mexico children were of two types, the Spanish Americans, descendants of original settlers, largely Spanish in origin, and the so-called Anglos, mostly of northern European descent. These two groups proved to be diverse in diet habits, body measurements, and blood composition. The mean heights and weights of the Spanish-American and the

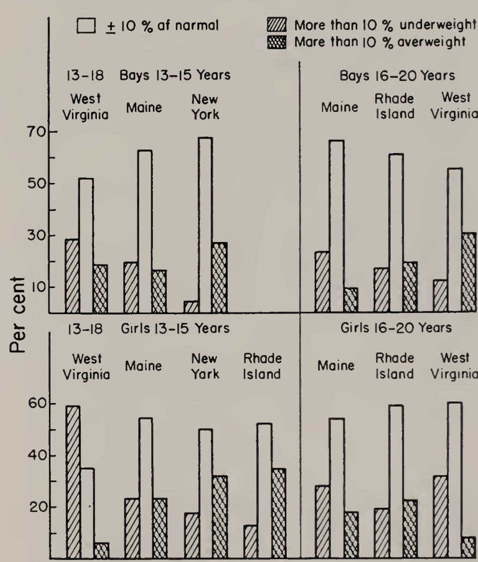



Fig. 63. Percentage of adolescents 13 to 20 years of age in four Northeastern states who were significantly under- or overweight.

**Many of the young subjects were most cooperative. On the left a nutritionist weighs and measures a school child; on the right a New York subject is being tested.**

Arizona Indian boys were significantly less than those of the other boys, and this was also true of the heights of the girls. The Arizona Indian girls, strangely enough, had much the greatest average body weight of any of the Western group. The Spanish-American New Mexico girls were, on the other hand, lighter in weight than any of the others. A significant correlation was found in the New Mexico study between the protein of the diet and the heights of the children. This was true of both sexes and both cultures. The average heights of 14- to 16-year-old Spanish-American and Anglo boys were 64.3 and 68.7 inches, of the girls 61.4 and 64.0 inches. The protein intakes of these two groups of boys were 77 and 101 gms. per day, of the girls 68 and 73.

### Weights and body build of Western adolescents.

Comparisons of the percentage of over- and underweight adolescents 14 to 16 years old were also made in five states in the West (fig. 65). More than 70 per cent of the New Mexico Anglo girls fell in the normal column with equal numbers under and overweight. The Washington, Idaho, Montana, and Colorado girls were much alike in that more than 50 per cent were in the normal weight range with somewhat more overweight than underweight. The Spanish-American girls in New Mexico were conspicuously underweight, 38 per cent, with 48 per cent in the normal column and 14 per cent overweight. The Spanish-American boys were even more underweight, 45 per cent, with

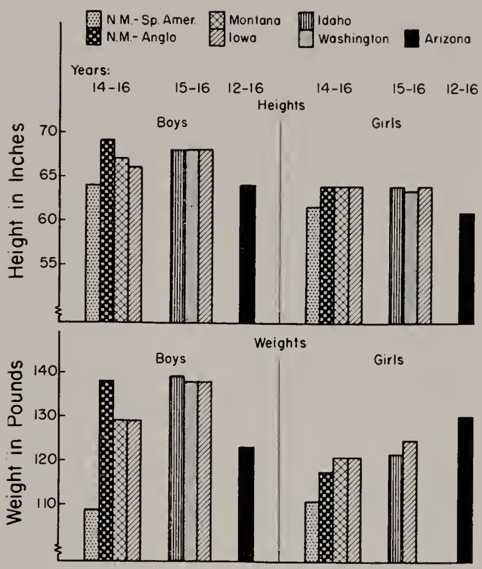



Fig. 64. Mean heights and weights of boys and girls 12 to 16 years of age in six states.

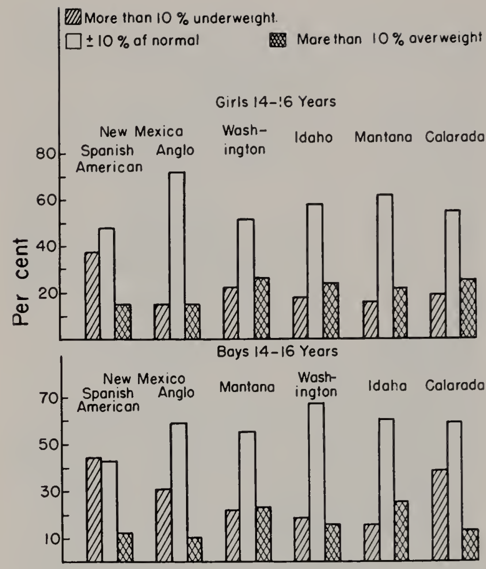



Fig. 65. Percentage of boys and girls 14 to 16 years of age in five Western states who were significantly under- or overweight for height, age, and sex.

only 12 per cent overweight. More New Mexico Anglo and Colorado boys were also underweight, 31 and 38 per cent, than overweight, 12 and 14 per cent. The other Western boys had fairly balanced numbers of under- and overweight.

New Mexico, Washington, and Idaho adolescents were classified as to physique channel, using the Wetzel Grid charts. There were no obese boys among the Spanish-American New Mexico subjects; only 4 per cent were stocky and 54 per cent thin or very thin. Among the Anglo New Mexico boys, 14 per cent were obese or stocky and 28 per cent thin or very thin. The division among the Washington boys was about the same as of the Anglos, but Idaho boys had 24 per cent obese or stocky and only 18 per cent thin or very thin. Whether racial stock, diet, climate, or other environmental factors govern these differences remains to be determined (fig. 66).

**Under- and overweight of adults.**

The North Central study of women over 30 years old and that made in California and Colorado on men and women over 50 yielded some figures on amount of under- and overweight in adults. The New Jersey study of 600 male industrial workers also included weight records.

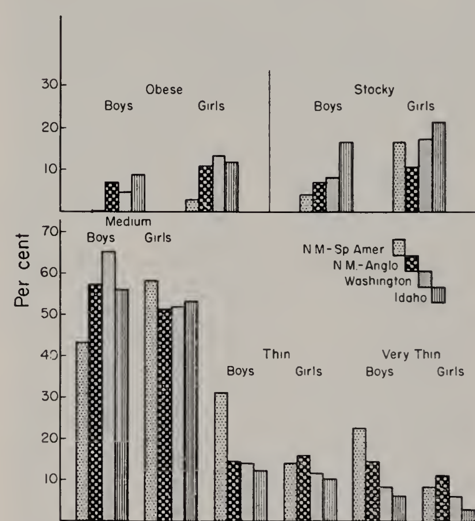



Fig. 66. Percentage of adolescents of various body builds in three Western states.

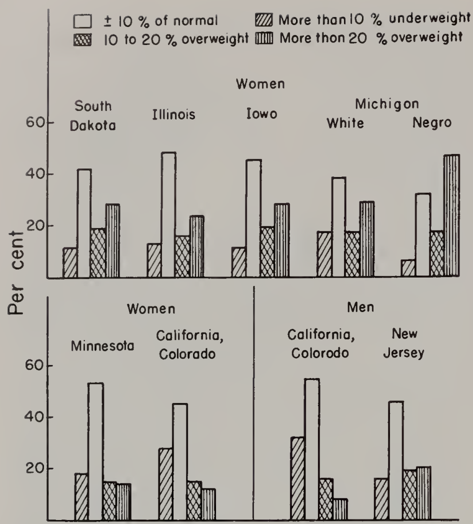



**Fig. 67. Percentage of under- and overweight among adult men in three states, and adult women in seven states.**

The North Central women, in South Dakota, Iowa, Illinois, and Michigan, showed relatively high percentages of overweight, the greatest, 47 per cent more than 20 per cent overweight occurring among the Michigan negro women. There were 23 to 25 per cent in this classification in the other North Central groups. Only 14 per cent of the Minnesota women, who were on the average older than the other North Central women, had this amount of overweight, as did only 12 per cent of the older women in the West (fig. 67). About 45 per cent of all the North Central women were more than 10 per cent overweight, compared with only 12 per cent who were underweight. The degree of overweight noted in the women in South Dakota and Iowa is significant because the sample chosen was fully representative of all the women in this age group in these two states. Also the incidence of overweight in the women studied in Illinois and Michigan is probably significant for these specific groups of urban women.

Only 6 per cent of the negro women and 11 to 17 per cent of the others in the North Central states were underweight. The California and Colorado women had a relatively high degree of underweight, 28 per cent. These western women were older on the whole than those in the North Central study since they were all over 50 years of age, instead of over 30 years as in the North Central states.

The New Jersey men 20 to 50 years old had less underweight and more overweight than the older California and Colorado men. Only 8 per cent of the latter were excessively overweight but 20 per cent of the former were. This is not unexpected because of the tendency for men to decrease in weight with advancing decades.

## SECTION 8

# Incidence of Physical Signs Sometimes Associated With Nutritional Deficiencies

A long and varied set of physical signs discernible by an experienced medical examiner has been listed as possibly related to nutritional failures of one kind or another. Many of these signs are interpretable in acutely varying ways, depending upon the experience and judgment of the examiner. In several of the cooperative studies, especially in the Northeast and the West, an attempt was made to conform to one list of such signs, each carefully described. Nevertheless, variability in the reports of the examiners was obvious and disturbing. The same examiner operated in California and Oregon, another in Colorado, New Mexico, and Arizona, two others in Montana, two in Idaho, and two in Washington. In the Northeast a competent physician conducted the examinations in each state and these examiners had the assistance of a special advisory committee of five experienced physicians. A group of three experienced physicians conducted the examination of the Louisiana preadolescent children and one well-qualified physician made all the observations in the similar Virginia study.

In spite of the general consensus that the symptoms defined and described vaguely as of nutritional origin are usually nonspecific and may be caused by several impinging deficiencies, by injury, disease, or other unrelated factors, the physical examination is considered to be worth while in assessing nutritional status. In any case, in these three regions the examinations were made and recorded.

The tissues studied are all external. Usually noted are condition of skin, particularly of the face; the eyes, especially the conjunctiva; the lips and mouth, tongue, gums; enlargement of thyroid; and sometimes the state of bones and teeth. The main signs noted were dryness or scaliness of the skin, overgrowth or roughening of the follicles, folliculosis. waxy deposits around the nose and lips, acne, crusted eyelids, thickening and inflammation of the conjunctiva (membrane covering eyeball and inner eyelids), swelling of the thyroid, inflammation and creases at the angles of the mouth, inflammation or reddening of the gums, and fissuring, roughening, or reddening of the tongue. In most cases if any sign was found, the degree of severity was also noted.

**These photos from the Northeastern Region show typical examinations of (top) mouth tissues, (center) skin and arms, and (bottom) eyes of children used in the tests.**

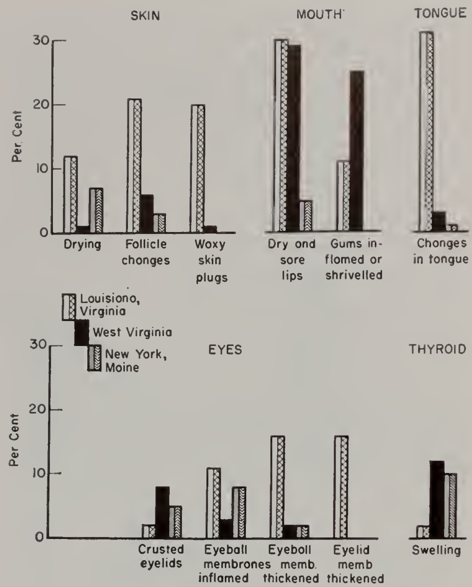



Fig. 68. Incidence of physical signs sometimes associated with nutritional deficiency in children under 13 years of age in Louisiana, Virginia, West Virginia, New York, and Maine.

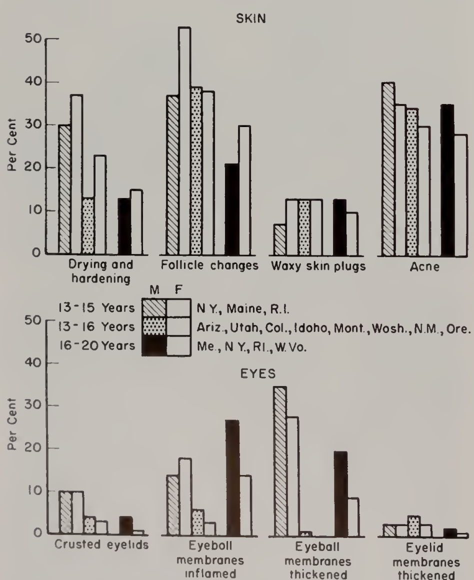



Fig. 69. Incidence of physical signs sometimes associated with nutritional deficiency in adolescents 13 to 20 years of age in four Northeastern and eight Western states.

Of the Southern children 8 to 11 years old (fig. 68), 12 to 21 per cent had scaly or roughened skin and naso-labial seborrhea (waxy deposit on skin of nose and lips), 30 per cent had roughening or creasing of the skin at the mouth corners and red or cracked lips (cheilosis), and 12 per cent inflammation, atrophy, recession, or swelling of the gums (gingivitis). More than 30 per cent also showed some changes in the tongue, and 11 and 15 per cent had inflamed or thickened conjunctiva. Very few New York and Maine children under 13 years of age showed any of these signs, but in West Virginia miners' families 28 per cent had cheilosis, 25 per cent had gingivitis, and 8 per cent had inflamed conjunctiva. Possibly because of difference in age the Southern children showed very little thyroid enlargement, compared with 10 to 12 per cent among the Northeastern groups.

Rather large numbers of boys and girls 13 to 15 and 16 to 20 years old were examined in the Northeast and in the West (figs. 69 and 70). In both regions more boys than girls had acne, 35 to 40 per cent as against 30 and 32 per cent, and more girls than boys showed skin

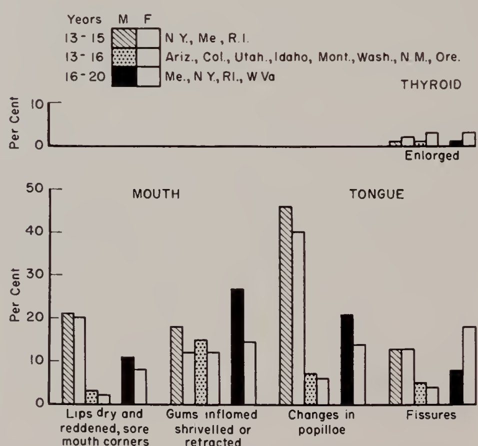



Fig. 70. Incidence of physical signs sometimes associated with nutritional deficiency in adolescents 13 to 20 years of age in four Northeastern states and eight Western states.

scaling, dryness, and follicle changes. The Western children had significantly less tongue, gum, and mouth changes than those in the Northeast. The same was true of inflammation and thickening of the conjunctiva. The older group, 16 to 20 years, in the Northeast, generally showed a decrease in incidence of these signs, some of which are possibly due to hormonal pubertal changes.

The male industrial workers in New Jersey and the men and women over 50 years of age in California and Colorado were also examined for these signs of possible deficiences (fig. 71). The older men and women in California had more drying and hardening of the skin than either the Colorado older people or the young and middleaged New Jersey men. Gingivitis occurred oftener in the men than the women and more in the older than the younger men. Changes in the tongue also were more frequent in the older group as were those in the conjunctiva. Ten to 15 per cent of the younger men in New Jersey had skin dryness, cracking skin at the angles of the mouth, tongue and conjuctival changes, but more than 20 per cent showed gum inflammation, atrophy, or retraction. The younger West Virginia subjects, college students over 20 years old, had few of these signs except for gingivitis in the men and thyroid enlargement in the women. Obviously, some at least of the superficial changes which have been ascribed to nutritional deficiencies, notably of vitamins A and C and riboflavin, are also characteristic of aging. It is difficult, therefore, to decide whether such changes are eventually inevitable or whether they may result from long-continued but slight dietary deficiencies.

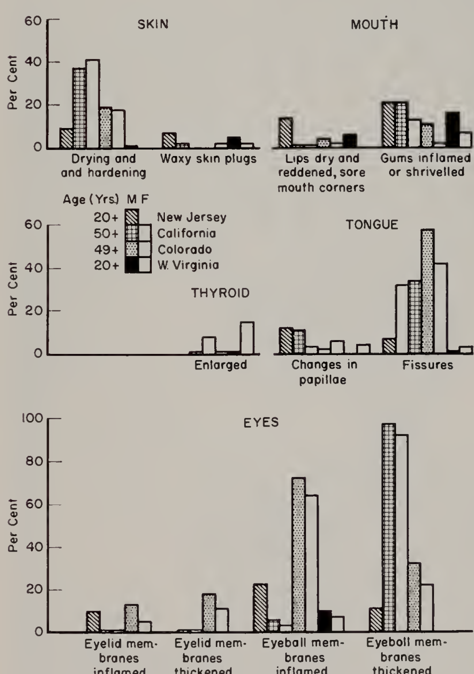



**Fig. 71. Incidence of physical signs sometimes associated with nutritional deficiency in adults 20 to past 80 years of age in New Jersey, California, Colorado and West Virginia.**

### Eye and skin signs vs. vitamin A and riboflavin nutriture.

The children under 13 years of age in Louisiana and Virginia had a greater incidence of both skin and eye signs than those in West Virginia and New York. The mean vitamin A in the diets was almost the same in all these groups, as was alto the mean dietary riboflavin. However, in comparison with New York and West Virginia, more than twice as many Louisiana and Virginia children received less than two-thirds of the recommended allowance of both vitamin A and riboflavin. The average blood vitamin A and carotene levels of the Southern children were also lower than those of the New York group (fig. 72).

In the adolescent groups, 13 to 15 years of age, the children in New York, Maine, and Rhode Island had twice as many showing skin signs and four times as many with eye signs as in the Western group of the same age. But the mean intakes of both vitamin A and riboflavin in the Northeast were equal to or larger than those in the West. Likewise, the percentage of boys and girls with less than two-thirds the recommended amounts of these two vitamins was about the same in the two regions. However, the mean blood vitamin A and carotene levels were both significantly higher in the Western than the Northeastern subjects. The older Northeastern subjects 16 to 20 years old had fewer cases of skin and eye signs than the adolescent, 13 to 15 years, Northeastern children, yet their intakes of vitamin A and riboflavin were less on the whole and a greater percentage had excessively low intakes. Again, however, their mean blood vitamin A and carotene levels were definitely higher than those of the adolescents. Clearly the blood levels are a better index of vitamin A and riboflavin nutriture than 7-day dietary records, no matter how carefully supervised, or else these eye and skin changes are unrelated to current vitamin intake, although perhaps influenced by long-time dietary habits (fig. 72).

The older men and women in California exhibited a higher percentage of eye and skin signs than did the Colorado old people or the middle-aged men in New Jersey. But their mean intakes of vitamin A and riboflavin were highest, and the percentage having less than two-thirds the recommended allowance of vitamin A and riboflavin was lower except for vitamin A in the New Jersey group. Their blood vitamin A, but not carotene values were higher than those of the New Jersey men. Obviously in older people long-time food habits may show more correlation of eye and skin symptoms with nutrient intakes, especially of vitamin A, than current dietary habits, or else other factors than those in food influences the health of these tissues increasingly with advancing age.

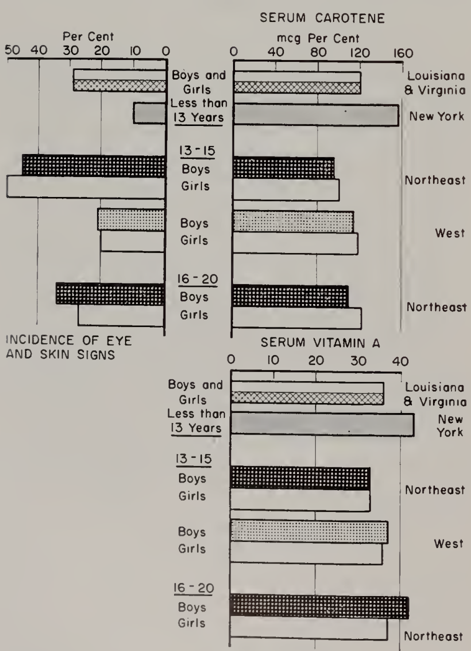



Fig. 72. Incidence in New York and two Southern states of eye and skin changes sometimes associated with vitamin A and riboflavin deficiencies, in children under 13 years of age, and in Northeastern and Western adolescents compared with their serum vitamin A and carotene levels.

### Mouth signs vs. ascorbic acid and riboflavin nutriture.

The mouth and tongue signs such as cheilosis (redening and angling of the lips) and gingivitis (gum changes) have long been thought to be associated with ascorbic acid or riboflavin intakes or metabolism. The young children in Virginia and Louisiana showed much greater incidence of these changes than did the New York children of about the same ages. The mean intakes of both ascorbic acid and riboflavin were however about the same. But the percentage of children at the lower end of the intake range was usually twice as great in the South as in New York. Also, the mean ascorbic acid level in the blood of the New York children was nearly twice that of the Southern children (fig. 73).

The Northeastern and Western adolescents 13 to 16 years old may again be compared. Mouth and tongue signs were recorded two or three times as often in the Northeast as in the West, but the mean ascorbic acid and riboflavin intakes were on the whole greater in the Northeastern group. The percentages of boys and girls having less than two-thirds the recommended amounts of the vitamins were greater in the West than in the Northeast. Nevertheless, the serum ascorbic acid levels in the West were definitely higher than in the Northeast. Perhaps blood will tell when records do not, or perhaps the mouth signs are irrelevant to ascorbic acid and riboflavin status.

Again, the older Northeastern subjects 16 to 20 years old showed fewer mouth signs than the corresponding adolescents. Again, their intakes of the vitamins were less and the percentage of cases at the lower end of the intake range was greater, but their blood levels were somewhat higher than those of the younger group. It is interesting to note also that the girls at all ages had higher blood ascorbic acid

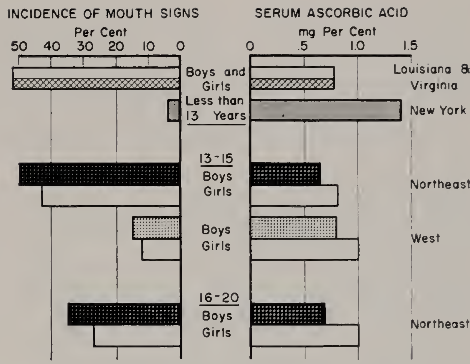



**Fig. 73. Incidence of changes in mouth, gums, and tongue sometimes associated with ascorbic acid deficiency in New York and Southern children under 13 years of age and in Northeastern and Western adolescents compared with their serum ascorbic acid levels.**

**Vermont children undergoing physical examinations.**

levels than the boys and also lower incidence of mouth signs of possible insufficiency.

About the same story repeated itself for the California, Colorado, and New Jersey subjects. There were more mouth signs of so-called deficiency in the California older men and women than in Colorado, and both of these had more than middle-aged New Jersey men, yet the ascorbic acid and riboflavin intakes of the California subjects were greater than the others and the percentage of California people with intakes lower than two-thirds the recommended allowance was lower than in New Jersey or Colorado. However, the serum ascorbic acid level was higher in the California than the New Jersey men and still higher in the California women. If the gum recession and retraction cases noted by the California and Colorado examiners but not by the Northeastern examiners are excluded from the count, the incidence of mouth signs is considerably greater in the New Jersey men than in the older California and Colorado men and women. The blood ascorbic acid levels are in the opposite order, California women and men having the higher levels, the New Jersey men the lowest.

It seems on the whole that these physical changs in skin, eyelids, conjunctiva, lips, gums, and tongue have limited significance as indications of the nutritional deficiencies which have been found to produce such changes under experimental conditions. Long-continued and severe deficiencies do produce these signs, but many other factors may also be concerned. For instance, of the 23 signs searched for in all the Northeastern subjects, the greatest incidence, 23 per cent, was found among the pregnant women in Massachusetts, the next, 18 per cent, among the Maine school children and college students. The Rhode Island school children had 11 per cent and all others much less. The pregnant condition in the first group, climate and diet in the second and third may be in part accountable for these differences. The greatest average incidence, 11 per cent, occurred in the 13- to 15-year-old children, the least in the children under 13. Incidence among girls on the whole was 10 per cent, among the men and boys 8 per cent. This is weighted by the group of pregnant women studied in Massachusetts.

The review of these population groups in the light of their dietary records, their blood composition, and the appearance of physical signs appears to support the view that the physical signs are only faintly related to the current nutrient intakes but fairly plausibly connected with the blood levels of certain vitamins, notably ascorbic acid, vitamin A, and carotene.

# PART II

# SOME SPECIAL STUDIES

The data presented in Part I were collected in all four regions on segments of the population by methods which were comparable enough to permit their common interpretation. In addition to gathering these data, however, many of the experiment stations undertook special studies of urgent or fundamental problems concerned with nutritional status. Some of these started with obvious public health problems connected with nutrition, and some with questions of theory, cause and effect, and mechanism of action of the nutrients. Five examples of each class are briefly described in the pages which follow.

In Class I are 1) the effect of nutritive quality of school lunches and of breakfasts and snacks on the nutritional status of children; 2) the amount and effect of under- and overweight in adults; 3) the relation of diet to nutritional status in pregnancy; 4) the extent, causes, and prevention of dental caries in school children and adolescents; 5) the density of bone of children and adults in relation to diet, age and sex.

In Class II are 6) some studies of the need of men and women for certain essential amino acids and the utilization of food sources of these amino acids; 7) studies of vitamin C utilization in men, women, and children, with reference to effects of diet, age, and sex; 8) the effect of age and sex on the level of cholesterol in the blood and its relationship to diet, altitude, and other conditions; 9) conditions which affect the value of carotene of vegetables and fruits as a source of vitamin A in the body; 10) levels of blood riboflavin and their relationship to diet.

## THE ROLE OF LUNCH, BREAKFAST, AND BETWEEN-MEAL SNACKS IN THE NUTRITION OF SCHOOL CHILDREN

The provision of a partly Government-subsidized lunch in many public schools has long been considered a major step toward the improvement of the nutritional status of the children. Definite objective proof of such improvement has not been readily obtainable, partly because of the variation in the home diets of the children and partly because of variation in the nutritive value of the school lunches provided.

### Iowa-Kansas-Ohio.

In both the Northeastern and the North Central regions an attack was made on this problem. The most elaborate and long-continued study was that carried out in Iowa, Kansas, and Ohio between 1947 and 1957. Many of the findings of this triple endeavor have been quoted in the preceding pages on nutrient intakes, blood composition, and body measurements. Among other things, it was shown quite clearly that neither advantage nor disadvantage in the blood components measured resulted from the participation of 9- to 11-year-old children in the lunch programs of their schools (fig. 48).

The average intake of calcium in some of the age groups was below the recommended allowance. Eighteen to 40 per cent of both boys and girls had less than two-thirds the recommended allowance of ascorbic acid, 12 to 33 per cent had similarly low intakes of calcium, and 10 to 25 per cent had low intakes of vitamin A. Only a small number of the children had diets which met the recommended allowance for all nutrients. The dietary intakes of these children on the whole cannot be classed as adequate.

Since the levels of ascorbic acid, carotene and hemoglobin in the blood of some of the children were low and the prevalence of dental caries was high, the nutritional status, also on the whole, cannot be called satisfactory.

**The Papago Indian study.**

In the Arizona study of 115 Indian children attending a public and a private school, clear differences in status, particularly as to vitamins A and C, were seen between the children who were given an ample, well-chosen lunch at the public school and those who had a much smaller, less adequate lunch at the private school. Since the home diets were marginal in value, the differences brought about by the lunches were readily observed. There were no perceptible differences between the two groups in height, weight, hemoglobin, red blood cell or white blood cell count, or blood serum riboflavin, protein, glucose, or cholesterol. The blood serum vitamin C, vitamin A, and carotene values were lower among those having the poorer lunch, and the bone density of these girls was less than that of the girls with the ample lunch (fig. 74).

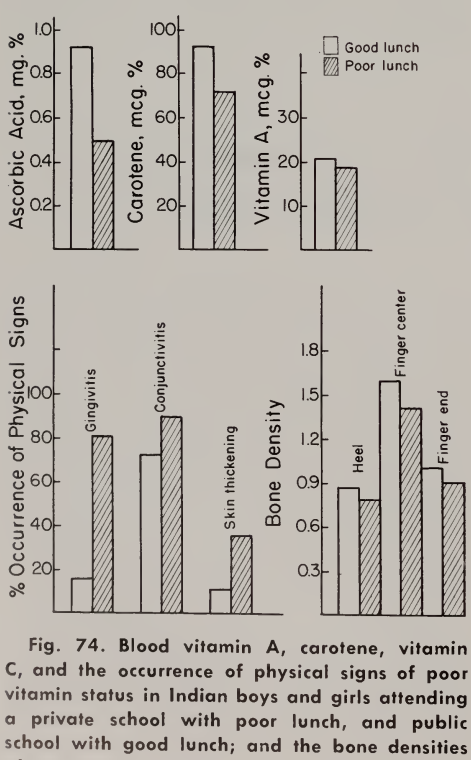



Fig. 74. Blood vitamin A, carotene, vitamin C, and the occurrence of physical signs of poor vitamin status in Indian boys and girls attending a private school with poor lunch, and public school with good lunch; and the bone densities of two groups of girls.

**The Northeast.**

In Bangor, Maine, 450 junior high school children were examined for physical signs possibly associated with nutritional deficits. Underweight, acne, reddened peeling lips (cheilosis), and gingivitis (inflamed gums) were more common among the boys than the girls, and overweight and rough dry skin (folliculosis) were more often found among the girls. Conjunctivitis, inflammation of the eyelids (blepharitis), and changes in the papillae of the tongue occurred about equally in the two sexes. More than a third of the children showed one or more of these defects.

Blood tests for vitamin C, vitamin A, carotene, and hemoglobin confirmed these findings. More than half of the girls and two-thirds of the boys were ranked only fair or poor in blood vitamin C, 80 per cent of both sexes was fair or poor in blood carotene, 39 per cent of the boys and 44 per cent of the girls were fair or poor in blood serum vitamin A. About a third were ranked fair but only four children were poor in hemoglobin levels. All others ranked excellent or good.

A 4-day record of the diet of the children revealed that more than half the boys and nearly 40 per cent of the girls had poor intakes of the vitamin-rich vegetables and fruits, 17 per cent of both were fair or poor in protein food intakes, but only 4 to 5 per cent of these were poor. Twenty-one to 28 per cent were poor in milk intake. Much sweet food, low in vitamins and proteins, made up the calorie quota. The blood values and physical signs reflected faithfully these dietary defects.

The type of lunch eaten by the children was then observed. These were 1) the school lunch as served; 2) the school lunch altered by omissions or additions; 3) a box lunch from home; 4) lunch at a neighborhood store; 5) lunch at home. There were 17 to 32 children in each of these lunch groups. The nutritive values of the various lunches were judged according to their provision of at least one-third of the recommended daily allowances of nine nutrients.

The school lunches as served were found to be generally deficient except for milk content and low in calories, iron, niacin, and ascorbic acid for the girls, and in thiamine also for the boys. For example, the boys often took extra servings when they were available. They also often added high-calorie foods, such as candy, potato chips, ice cream, and cookies. The girls sometimes omitted all or part of the milk.

The box lunch brought from home was still more deficient. On the average, it contained less than a third of the recommended amounts of all nutrients except protein, calcium, thiamine, and riboflavin for the boys, and thiamine, riboflavin, and niacin for the girls. Iron, vitamin A, and ascorbic acid were most notably missing. For neither group did the home diets provide in the other two meals enough nutrients to make up these deficits.

The lunches bought in a neighborhood store were deficient in all nutrients and usually contained only 10 to 20 per cent of the recommended amounts of all the nutrients. The home diets of this group of children were the poorest of all groups studied.

The greatest percentage of children who received in their three meals at least 80 per cent of the recommended allowance of nutrients occurred in the group who ate the hot school lunch; those who ate at home or brought a box lunch were intermediate, and those who bought a store lunch fared the worst. More than half the girls had diets deficient in vitamin C, and this was true of the boys also except for the box-lunch group and the group who ate a modified hot lunch.

There followed a recommended revision of the hot school lunch so that with appropriate additions and exchanges the lunch furnished a third of the day's allowance of nutrients. The chief additions were of raw and canned spinach, tomatoes, and citrus fruit. Larger portions were served to supply the missing calories, and extra bread, butter, peanut butter, and jam were given the boys especially. These revised lunches met the Type A requirements of the federal school lunch program and provided between 40 and 60 per cent of the daily allowances for vitamin C, niacin, thiamine, and iron and over 100 per cent of the daily allowance for vitamin A. These nutrients had been found to be those most likely to be low in the home meals of the children.

A supplementary study of the breakfast habits of 57 Maine teen-agers was carried on in three communities. The breakfasts, especially those of the girls, were apt to be low in calories, protein, iron, vitamin A, and niacin. Milk, bread, cereals, and citrus fruit or juices made up most of these breakfasts. About 40 per cent of the children had less than 15 per cent of the recommended daily allowance of vitamin C in their breakfasts, and the daily intakes as a whole were deficient in vitamin C, calcium, iron, and calories. The inadequate breakfasts tended to result in deficiencies in nutrient intake for the whole day. The school lunches and breakfasts of the Maine junior high school students on the whole were low in calories, iron, niacin, and vitamin C. Meat, eggs, citrus fruit, tomatoes, and whole grain or enriched bread and cereals supply these nutrients.

Maine junior high school students in line for the school lunch.

Here Rhode Island high school girls select a school lunch.

Breakfast and between-meal foods of 316 adolescent boys and girls in Maine, New York, and Rhode Island were examined for nutrient value. Seven-day dietary records were studied. Breakfasts contributed only one-fifth of the recommended daily allowances of nutrients in all three groups. Fifty per cent or more of the children consumed one-fourth or less of their daily intakes of calories and protein at breakfast. The boys as a rule ate more satisfactory breakfasts than the girls, and the children who always ate breakfast more nearly met the recommended allowances than those who missed breakfast once a week or more.

Between-meal snacks contributed 10 per cent or less of the daily nutrient intakes of the junior high school Maine and New York children but such snacks were more important to the Rhode Island high school children since they contained substantial contributions to the intakes of calories, protein, calcium, and phosphorus.

**Costs and adequacy of lunches in an Iowa school.**

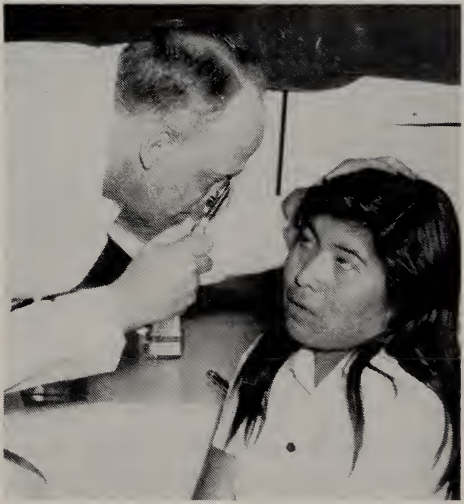
A pilot study of the nutrient values, waste, and costs of the lunches served in an Iowa rural school revealed some discrepancies in service to the 200 children in the various grades. The lunches eaten by children in grades 1 to 3, 4 to 6, and 7 to 12, inclusive, were studied separately. About half the lunches served to the children in grades 1 to 3 met the criterion of adequacy, that is, contained one-third of the recommended daily allowances of nutrients for that age range, one-tenth met this criterion for grades 4 to 6, and none for grades 7 to 12. This was because the youngest children were served first and were allowed to determine the size and number of portions served. By the time the older children were served, shortages usually appeared in the more popular items.

A boy in the Iowa-Kansas-Ohio school lunch study is given a hand grip test.

The greatest deficit in the lunches as served was in vitamin A, the least in vitamin C.

**A survey of 25 schools.**

In another survey, 25 public schools were chosen for study in Iowa as representing statistically the 622 schools of that state. Significant differences in labor time, in kitchen and serving area, and in



A doctor examines the eyes and eyelids (conjunctiva) of an Arizona Indian girl.

costs were found among the three groups of schools, elementary, high, and 12-grade schools. The daily average number of paid-for lunches served during the year was 19.7. Six per cent of type A lunches were served free to pupils, and the average price charged to the other pupils was 22.6 cents. About 34 per cent of all pupils participated in the school lunch. The range was from 10 per cent in a large city school to 96 per cent in two small 12-grade schools.

Plate waste averaged 0.9 ounce, with more return of salads, vegetables, and main dishes, 8 to 12 per cent, than of milk or desserts, usually 2 to 4 per cent. The fruit juices were completely consumed. On the one day of observation, in none of the schools did the standard portions of food supply the one-third of the recommended daily allowances of nine nutrients which Type A lunches should supply. Food energy (calories) and iron were the nutrients most often inadequate.

Per hour of labor time, preparing, serving, and cleaning, 7.9 revenue lunches were served and 7.2 lunches per minute were served per serving line at peak load. Kitchen space per daily number of revenue lunches averaged 2.3 square feet (range, 0.6-8.5). This met the recommended 1.5 square feet in 19 schools. The recommended 9 square feet of dining room space per seat was met in only nine schools.

More than half the schools had good refrigerators and ranges, fewer than half had good dish-washing facilities. These differences in equipment were reflected in labor time and menus.

The total income in all schools averaged 27 cents per lunch (range, 16 to 47 cents). The chief source of income was the sale of lunches at average price of 21 cents (range, 9 to 36 cents). Federal reimbursement averaged 4 cents, sale of milk and other extra food items 2 cents, and all other sources 1 cent. But the total average cost of the lunches was 26 cents, divided as follows: food, 15 cents, labor 8 cents, other costs 3 cents. Thus income and costs were fairly balanced.

### Distribution of food eaten among meals by Iowa children.

The Iowa group also studied the distribution of nutrients between meals and snacks of school children. Breakfasts contributed only 15 to 20 per cent of the total calories for the day, lunches 32 to 34 per cent, dinners 33 to 35 per cent, and snacks 13 to 17 per cent. The older girls tended to have fewer calories at breakfast and obtained more through snacks. The breakfasts were generally low in vitamin A and niacin, the dinners in calcium and ascorbic acid. Most of the breakfasts provided 10 per cent or more of the day's protein. These calorie-low, protein-low breakfasts of so many children were considered a definite nutritional problem requiring further study. For certain age groups the between-meal snacks which provided as many calories as the breakfasts were also high in carbohydrate and low in all other nutrients except ascorbic acid.

The diets of the 1188 children, from 6 to 18 years of age, were classified as to their nutrient values in terms of the recommended allowances. In Class I all nutrients were provided in amounts of 100 per cent or more of the recommended allowances; in Class II, some were less than 100 per cent but none was present in less than 67 per cent; and in Class III, at least one nutrient was present in less than 67 per cent of the recommended allowance. The differences among the diets of classes I and III could not be ascribed to any one of these meals, but rather to low-calorie meals, generally poor in nutrients.

Another analysis of the foods eaten by these 1188 Iowa children showed that one-half to two-thirds of the breakfasts were predominantly poor by the criteria used. Too little milk, fruit, meat, and eggs were used. Since bread and breakfast cereals and their accompaniments often made up the breakfasts, the nutrient intakes depended on the choice of these cereal foods. The use of milk by the rural children was notably poor, as was also that of milk and eggs by nearly all the older girls. The boys ate more as they grew older, but the quality of the diets was not improved. In general, poor breakfasts were associated with poor total diets.

**The school lunch program in Ohio.**

A survey of school lunch service made in Ohio in 1948 covered 288 of the 1400 school lunch programs of that state. Of these, 216 were federally supported, that is, they received financial aid from the U. S. Department of Agriculture through the Ohio State Department of Education.

It was found that 45 to 50 per cent of the children ate a hot lunch when it was offered at school. Most of the schools offered a planned plate lunch, including milk, at a cost of 23 cents in the federally aided schools and 27 cents in the non-federal programs. Over one-third of the schools served only whole milk but 62 per cent served both whole and chocolate milk.

The lunch habits of 3813 high school students were noted. About 3 per cent ate no lunch, 32 per cent ate the school lunch at an average cost of 26 cents, 12 per cent a restaurant lunch costing 45 cents, 4 per cent a drug store lunch costing 39 cents, 35 per cent went home, and 15 per cent brought a box lunch from home. The children who ate no lunch spent 16 cents for between-meal snacks. More than 40 per cent of all the children bought snacks, but 75 per cent of those who ate in restaurant or drug store spent money for snacks.

A later study in 1954-55 concerned the amount of plate waste in the school lunches. Plate waste of about 200 children in grades 1 to 8, served a Type A lunch, was weighed for a total of 28 days in three periods in October, November and April-May. The mean percentage of waste for these three periods was 7.0, 6.4 and 5.8 per cent. Waste of milk was much less than of other foods, varying from none in the 4th grade children to 4.6 per cent during one period in the 8th grade. Total plate waste was always highest in grade 1, least in grades 4, 6, and 7. The amount of waste tended to decrease from the first to the last part of the school year. Meat loaf, baked ham, and barbecued beef sandwiches were returned more often than ground bologna, chicken, or wiener sandwiches.

The next year a new study was made to discover the relative amounts of waste in different kinds of vegetables, fruits, desserts, and protein-rich foods. The highest percentage of plate waste, no matter how calculated, occurred in vegetables and the lowest in desserts. Peas, sweet potatoes, and gelatin-vegetable salads were rejected most often, with about 20 per cent left to the plate. Waste of frozen vegetables was about 16 per cent, of canned vegetables 11 per cent, of raw vegetables 14 per cent.

Wieners, hamburger patties, and ground bologna were quite completely consumed, but 7.4 per cent of other high-protein foods, such as fish, eggs, and pork, and 15.8 per cent of mixed chicken and rice, chicken pie or loaf, and tuna salad were rejected. About 9 per cent of the fruit and 10 per cent of fruit desserts were returned.

Children in grades 1 and 2 returned more food than any of the other groups. They accounted for 61 per cent of the total dessert waste and about 40 per cent of all the other waste. First, 2nd, and 6th graders were responsible for more than half the total plate waste.

Methods of decreasing waste through choice of food, method of preparation, and size of serving were developed.

Obesity often has been said to be the outstanding nutritional disease in the United States. Numerous surveys, chiefly by insurance statisticians, have revealed that 25 to 30 per cent of the adult population is 10 per cent or more overweight and that mortality from heart disease is 40 per cent higher among moderately overweight and 65 per cent higher among markedly overweight persons than among those in the standard weight range. Overweight has also been associated with the development of high blood pressure, and the combination of overweight and high blood pressure may be accompanied by the early appearance of various types of heart disease. Interestingly enough, this association of obesity with arteriosclerotic and other heart disease is far less obvious in women than in men.

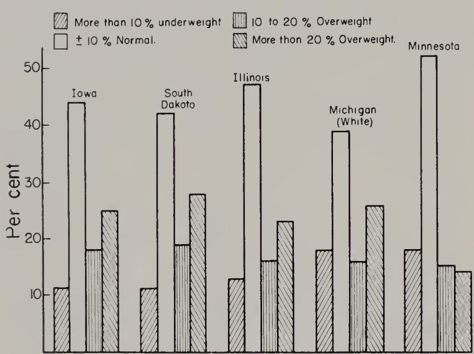



**Fig. 75. Percentage of over- and underweight in North Central women.**

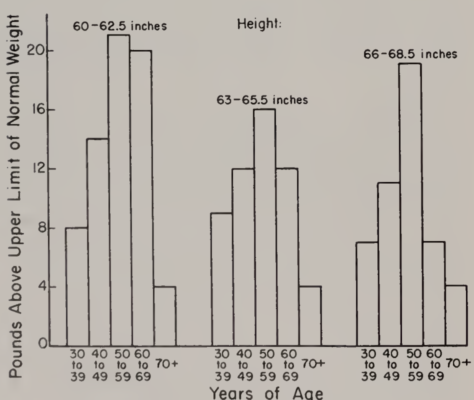



**Fig. 76. Amount of overweight of Iowa women 30 to past 80 years of age, of three height ranges.**

The incidence and degree of obesity among women over 30 years old in the North Central region was observed in connection with the dietary studies on these women. Fifteen to 20 per cent were moderately overweight, that is, 10 to 20 per cent over the desirable weight for height, and 20 to 30 per cent in addition were excessively overweight, that is, more than 20 per cent over the so-called standard weight. The exception was in Minnesota, where only 14 per cent were excessively overweight (fig. 75). Standard weight is here defined as the normal or desirable weight for height at age 25 (fig. 76). Overweight was most prevalent in the 50- to 59-year-old women and least prevalent in those past 70.

**Ailments and overweight.** The general health of the overweight women appeared to be less good than that of those who were normal or underweight for height. This was shown by the number of complaints or ailments reported by the women themselves. Such troubles as shortness of breath, pain and swelling in joints, high blood pressure, constipation, ulcers, indigestion, fatigability and headaches were reported, as well as serious symptoms such as gall bladder attacks, "stroke," "heart trouble." If a woman reported that she had sought medical attention for an ailment, double value was assigned to that ailment in the tabulation. Among women of desirable weight, the number of ailments increased from 2.0 per person in the 30-to 39-year age group to 3.6 in those past 70. The women who were more than 20 per cent above desirable weight reported more symptoms at earlier ages than did those of normal weight. Even though these are subjective ratings, their suggestions of a relationship between overweight and gradations in vitality and well-being are of interest. (fig. 77).

Of a group of 54 white and 36 negro women between 40 and 90 years of age studied in 1948 and again in 1955 in Michigan, about 40 per cent of the white and 60 per cent of the negro women were classified as overweight. Low intake of calories and poor-quality diets were common among the overweight subjects. Ailments such as unexplained tiredness, pains in the joints and shortness of breath were reported by more than 40 per cent, and these ailments were more numerous among the women with low intakes of nutrients, particularly vitamin A and ascorbic acid. Mortality rates for the six years between the examinations of these women were higher for the negro women than for the white women, and in both groups they were higher for those who reported intakes of less than 40 per cent of recommended quantities of one or more nutrients than among those with larger intakes of nutrients.

**Overweight and food intake.** A persistent and unexpected inverse relationship between obesity and calorie intake was noted by the North Central workers. In figure 78, the average calorie intake of the women of four weight groups studied in five states is presented. In each state sample, the women who were more than 20 per cent overweight reported the day's

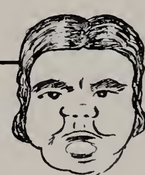
| Age Years | Ailments per Person | |
|---|---|---|
| | Normal Weight  | Over Weight  |
| 30–39 | 2.0 | 1.9 |
| 40–49 | 2.1 | 3.2 |
| 50–59 | 2.2 | 3.3 |
| 60–69 | 3.2 | 3.4 |
| 70 Plus | 3.6 | 3.3 |
| All Ages | 2.5 | 3.1 |

Fig. 77. The number of ailments reported by normal and overweight Iowa women of various ages.

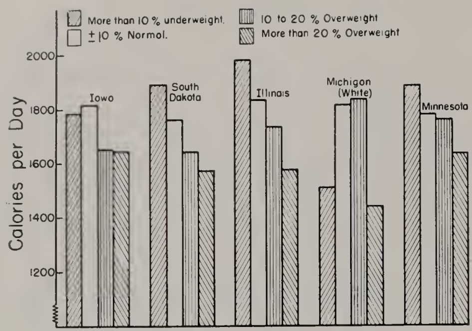



**Fig. 78. Average daily calorie intake by North Central women who were of normal weight, or under- or overweight.**

dietaries with the lowest mean energy value, the underweight and normal weight women generally the highest mean energy values. This was only partly explained by the attempt at reducing which some of the women reported. In one group of women, those who were trying to lose weight consumed foods yielding 1200 calories per day, those who were not attempting to reduce, 1700 calories. Moreover, the nutritional inadequacy of these reducing diets was striking.

The accuracy of comparable reports of food intake was checked at the Iowa station by comparison of the one-day recall calculated records of another group of women with those of weighed food intakes for seven days and with actual calorie determination by heat of combustion measurements of two days' intake. These three types of daily calorie-intake records yielded respectively the mean figures, 1735, 1715, and 1711. The uniformity of the reports of calories consumed throughout the region also lends credence to the comparisons. The average calorie intake of 339 South Dakota women was 1705, of 1072 Iowa women 1735, of 457 Illinois women 1780, of 97 white Michigan women 1664, 104 negro Michi-

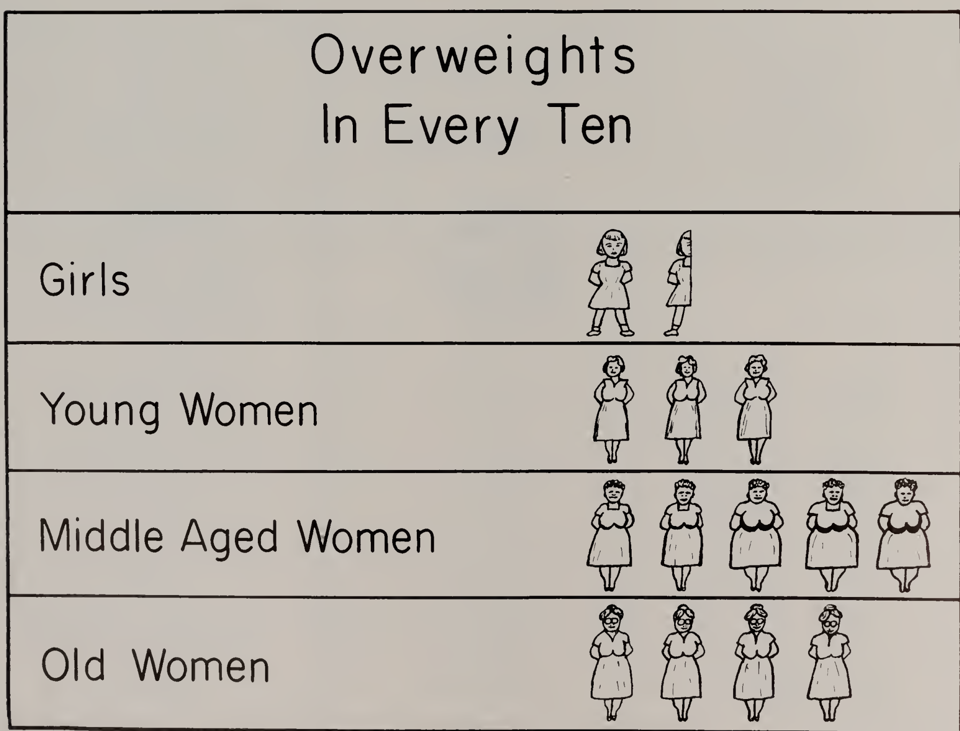



**Fig. 79. The increasing amount of overweight with age among Iowa girls and women.**

gan women 1071 and of 120 Minnesota women 1780.

The explanation for the low energy intakes of the overweight women offered by the researchers is that the physical activity of homemakers in town and country must have greatly decreased in the 50 years since the early estimates of women's calorie needs were made, when 2100 to 2300 calories was deemed necessary. The steady increase in overweight up to age 60 (fig. 79) shown by these women may be due to the accumulated excess of calorie intake over energy output due to custom and extension of early appetite. The decreases in average weight after age 70 may well result from the longer life span of the less overweight population, or it may represent a true physiological change in body weight in response to changes in endocrine function. In any case, food intake of these overweight women was surprisingly low and in many cases poorly chosen. The poor nutritional quality of these low-calorie diets may have produced actual loss of protoplasmic tissue without decreasing the fat deposits. Experiments with animals have indicated this possibility.

The California and Colorado women and men over 50 years of age had less overweight members than these North Central women; 28 per cent of the women and 24 per cent of the men were 10 per cent or more overweight. Only 12 and 8 per cent respectively were excessively overweight, that is, 20 per cent or more overweight for height. Of the still older group of Wyoming women, all over 60 years of age, 56 per cent were overweight. This is somewhat greater than the amount of overweight, 39 to 47 per cent, found in the North Central women.

Of the 600 New Jersey men, 20 to 50 years old, 19 per cent were more than 10 per cent overweight and 20 per cent were more than 20 per cent overweight. The difference from the California and Colorado figures may be ascribed to the younger average age of the New Jersey men. The California and Colorado men and women also had significantly more underweight members than the North Central women or the New Jersey men.

**Summary.** It is obvious that overweight is of frequent occurrence among adults, especially women, but that the amount varies widely. One quarter to one half of all the women examined in widely separated parts of the country were 10 per cent or more overweight, and more than half of these in turn were more than 20 per cent overweight. The sampling of men was smaller but the overweight found was about the same, 24 per cent in California and Colorado and 39 per cent in New Jersey, with about half of these excessively overweight.

The daily calorie intake of the women was found to be about 1700 on the average, considerably less than the 1800 to 2200 calories of the recommended allowances. The conclusion of the North Central group of researchers was that the energy requirements of modern women must be less than those estimated by the early workers in this field.

## NUTRITION IN PREGNANCY

As part of the Northeastern nutritional status research the Massachusetts station chose to study the nutrition of pregnant women. They examined the diets, blood, and urine composition of 79 women during early and late pregnancy and in the fourth month post-partum, that is, after the infant was born. About 70 per cent of the women took a mineral-vitamin supplement containing calcium, phosphorus, iron, thiamine, riboflavin, and vitamin D.

The hemoglobin levels of about half the group were in the lower normal range, and the mean levels during pregnancy were lower than after delivery. The women who took no iron supplement had protein intakes of only 54 gm daily and had lower hemoglobin than the others. In late pregnancy correlations between dietary iron and protein and hemoglobin levels were established.

Blood vitamin A and carotene levels were also in the lower range for 25 to 33 per cent, but there was an increase in the carotene levels in the ninth month of pregnancy.

Ascorbic acid intake, serum level, and urinary output were significantly correlated. About one-third of the women had blood levels below the normal range. This is about the proportion of such levels found in other segments of the Northeastern populations sampled. The urinary excretion of ascorbic acid was decreased post-partum, probably due to decrease in intake.

The excretion of thiamine in the urine was related to the intake. Between 10 and 20 per cent of the women excreted thiamine in amounts which indicated an inadequate intake. Riboflavin excretion was also related to intake, but none of the women excreted amounts indicating an inadequate supply of the vitamin.

No relationship was found between birth weights and lengths of the infants and adequacy of the mothers' nutrient intakes, including protein intake.

These results and the dietary studies point to protein, calcium, iron, ascorbic acid, and vitamin A as the nutrients present at critical levels in the diets.

Calcium intake was the lowest of all nutrients in comparison with the recommended allowance. Sixty-three per cent of the women had less than two-thirds the recommended amount, and even with the mineral-vitamin supplement the average intake was less than three-fourths the recommended amount, which is 1.5 gm daily for the last three months of pregnancy. Forty per cent of the women had less than two-thirds the recommended allowance of riboflavin and iron, and 30 per cent of protein, thiamine, and ascorbic acid. The supplement made up the deficit, on the average, for iron, riboflavin, and thiamine, but the protein and ascorbic acid deficits remained unalleviated.

Amount of money spent for food and total income appeared to have little relationship to the adequacy of the diets. Socio-economic factors, chiefly educational, perhaps, were of more importance. The diets chosen by the women post-partum were closer to adequacy, especially in milk and citrus fruit. than were those used during pregnancy. Apparently the instruction in nutrition accompanying the study had some effect.

Special attention was given to the relationship of tryptophan, one of the essential amino acids, with the utilization of niacin, one of the B vitamins, which is interrelated with tryptophan. There had been some evidence that this interrelationship was different in pregnancy from that of the normal nonpregnant state. The urinary output of the end products of niacin and tryptophan metabolism was found in these women to be considerably greater in pregnancy, especially late pregnancy, than in the late post-delivery period. The output of these end products often exceeded the equivalent of the total intake of niacin, both that in the diet as such and that which was thought to be obtainable from the tryptophan of the dietary protein.

To test this further, 500 mg doses of tryptophan were given to 12 pregnant women for 14 days. All end products of niacin and tryptophan were excreted in increased amounts except that of "free" typtophan, which decreased. When this supplement was given post-partum there was a similar but much smaller increase.

These observations appear to indicate that the conversion of tryptophan to niacin is more efficient in the pregnant than in the nonpregnant woman. This may represent a protective mechanism.

The urinary excretion of tryptophan and of seven other essential amino acids by 13 pregnant women was investigated next at this station. All the amino acids were excreted in greater amounts during pregnancy than post-partum. Threonine and tryptophan excretion was doubled or trebled in early and late pregnancy compared with the nonpregnant state, and that of the other amino acids increased from 3 to 118 per cent. The amount of excretion was not generally related to protein intake, weight, or age. These observations are of special interest because they were the first in which amino acid excretion was measured in the same women in the pregnant and nonpregnant states. Obviously the utilization of threonine and tryptophan is different and less economical in the pregnant than in the nonpregnant women. The provision of adequate amounts of these amino acids through the use of enough good protein foods, such as eggs, meat and milk, in the diet is indicated.

Although complications of pregnancy occurred in all the groups, the percentage of women who had such symptoms as nausea, anemia, edema, and other complications was less in the group whose diets supplied at least two-thirds of the recommended allowances of all nutrients, 32 per cent of the group, than in those who had less than this amount of at least one nutrient, 47 per cent of the group (fig. 80).

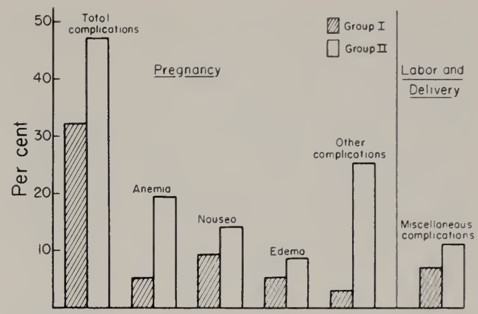



**Fig. 80. Group I: women whose diets contained at least two-thirds the recommended allowances of all nutrients (41 women). Group II: women whose diets had less than two-thirds the recommended allowance of at least one nutrient (36 women).**

### The Wisconsin study.

A study of intake and output of vitamin $B_6$ was made at the Wisconsin station on six nonpragnant and four pregnant young adult women. The diets were self-chosen and were weighed and analyzed during a 5-day period in each of the last three months of pregnancy and after the birth of the infant. The nonpregnant women were similarly studied during a total of 15 five-day periods. The intakes averaged 0.86 mg vitamin $B_6$ per day for the nonpregnant, 1.39 mg for the pregnant, and 1.06 mg for the post-partum cases. The output of vitamin $B_6$ and its end product in the excreta in all cases was two to four times the intake and was not essentially different in the pregnant and nonpregnant subjects. The authors interpreted these and other experiments to mean that vitamin $B_6$ is synthesized in the body, and that this synthesis acounts for the difficulty experienced in producing a deficiency of this vitamin in adult human subjects. The nonpregnant women showed a marked nitrogen loss in 9 of the 15 periods, something which the authors believe could have been avoided if the vitamin $B_6$ intakes had been more generous.

A later improvement in the method of determining the amount of 4-pyridoxic acid, the chief end product of vitamin $B_6$, proved, however, that other fluorescent compounds in the urine accounted for 40 to 70 per cent of the substances previously assessed as resulting from vitamin $B_6$ metabolism. Actually, the output after known intakes of the vitamin in natural diets was about 40 per cent of the intake.

The error involved in using the older methods in this attempt at a balance of intake and urinary output of the chief end product of vitamin $B_6$ was greater the lower the vitamin $B_6$ in the diet.

Much more work is needed on the intakes, outputs, utilization, and functions of this vitamin, $B_6$, or as it is sometimes called, pyridoxine. The diets reported as satisfactory in these cooperative studies were not analyzed for probable $B_6$ content, nor has any daily allowance been recommended for it. Until the dietary studies include values for vitamin $B_6$, and probably also pantothenic acid, our confidence in them canot be complete.

## DENTAL CARIES

Five of the Western stations made a well-planned cooperative attack on the prevalence and causes of dental caries in high school children. Only native-born-and-reared boys and girls were studied, and biochemical, physical and dietary studies accompanied the dental examinations. The dental caries experience of freshmen entering the five state colleges or universities was first determined as a basis for choice of areas for the survey.

Boys and girls 14, 15, and 16 years old, born and reared in eleven areas, were chosen. These areas were Coeur d'Alene, Boise, and Nampa in Idaho; Bozeman and Great Falls in Montana; in Oregon, two coast counties, two in the Willamette Valley and two in central Oregon; Ogden in Utah; and a coast and a central county in Washington. Altogether, 2068 children were studied.

A travelling laboratory trailer was used in the Oregon study with a team of nutritionists, biochemists, a doctor, dentist and X-ray technician. The methods of examination used throughout the region were largely established and confirmed by this group. Bite-wing radiographs of the teeth, one on each side, were taken to supplement the usual dental examination. These X-rays greatly increased the accuracy of the examinations and revealed 29 per cent more cavities than the usual methods. The results were expressed as DMF, number of decayed, missing, or filled teeth per person. The regional field study continued for five years.

### Effects of geographical and climatic factors.

The effects of the widely varying geographic and climatic conditions were assessed. Altitudes varied from sea level in Oregon and Washington to over 4000 ft. in Utah, Central Oregon, and Montana; mean annual relative humidity varied from 45 to 80 per cent; mean precipitation from 7.2 inches in Yakima County, Washington, to 70 inches in the Oregon coast counties. In the eight areas with low fluoride in the water the number of DMF teeth appeared to be increased with higher latitude, decreased with higher elevations, and in some cases decreased with greater amounts of sunshine. In this discussion low fluoride includes those areas with fluoride concentrations of 0.0 to 0.3 ppm. Little relationship could be found between number of DMF teeth and amount of precipitation, relative humidity, and temperature range. Complications due to increased radiation at the seacoast and in high altitudes, and the varying amounts of clothing worn by the children in the areas of different sunshine, temperature, and precipitation made the interpretation of the climatic and geographical factors difficult.

### Effect of diet.

The effect of diet upon caries was considered in these five states. More than 60 per cent of the 739 Oregon children had diets which met the recommended allowances for all nutrients except ascorbic acid and iron. In the other four states a much higher percentage of boys than girls had diets that were relatively satisfactory in comparison with the recommended allowances, but over a third of all boys and girls had low ascorbic acid intakes. Only a tenth or less of the boys had low intakes of any other nutrient, but half the girls had low intakes of iron and one-fifth to one-third also had low intakes of all the other nutrients studied except protein and niacin. There was not much variation of diet among the areas. The amounts of candy, carbonated beverages, and total carbohydrates were the same in all areas. On the whole no clear effect of diet upon the DMF rate could be seen.

**Effect of fluorides in the water supply.**

The fluoride in the water supplies of the 11 areas varied from 0 to 1.5 ppm. Concentrations of 0.1, 0.2, or 0.3 ppm did not reduce the incidence of caries when compared with the effect of fluoride-free water, but 0.5 ppm produced a definite decrease, 39 per cent in the Boise, Idaho, and Gervais, Oregon, groups as shown in figure 81. In Great Falls, Montana, where the water contained 1.0 ppm fluoride the caries incidence was further reduced by 55 per cent, and in Nampa, Idaho, with 1.5 ppm in the water, the reduction was 61 per cent. All these children had lived in the same areas and had consumed the water since birth. In the areas with 1.0 and 1.5 ppm fluoride in the water 13 per cent of the children were caries-free. In the areas with low-fluoride water less than 1 per cent were caries-free. However, the actual percentages of children with decayed, missing, or filled teeth in the areas with 1.0 and 1.5 ppm fluoride were not significantly different. Probably optimum protection was afforded by 1.0 ppm.

This significant and striking relationship between the fluoride of the water and the incidence of dental caries is similar to findings in other studies in this country and abroad. The benefits to the children of these moderate concentrations

**In Oregon, a dentist examines a child's teeth and (right) a nutritionist gets a dietary record from a boy in the dental caries study.**

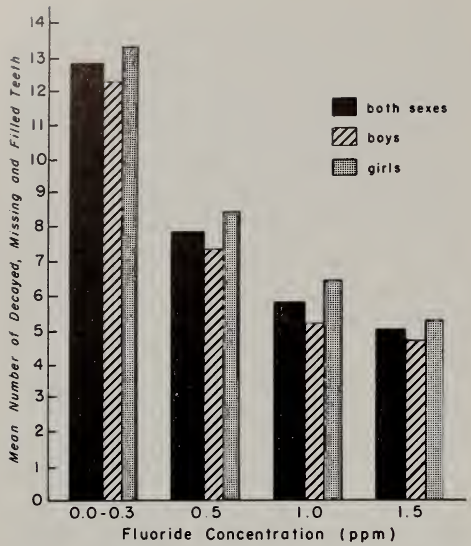



**Fig. 81. Mean number (without radiographs) of decayed, missing, and filled teeth for children classified according to the concentration of fluoride in the municipal water supplies.**

of fluoride in the water supply are striking. (fig. 81).

### Effects of hardness of the water supplies.

An inverse relationship between hardness of the water and dental caries experience has been suggested. This may be due to the calcium carbonate of the hard waters or to the presence of some other component, not fluoride, with a caries-resistant influence.

To investigate this possibility the Western group studied the total hardness of the waters used in the low-fluoride areas. There appeared to be a moderate decrease in caries incidence in the children who received water of increasing hardness, from extremely soft with 13.9 DFM teeth, to soft with 12.6, moderately soft with 13.5, hard with 12.9, and very hard with 11.5.

In the fluoride areas this effect of hardness was not apparent, since the fluoride factor overwhelmed any differences which might have been attributable to hardness.

### Incidence of dental caries in these states.

The amount of dental caries in the adolescents living in the 11 areas studied was high when compared to most epidemiological studies of the same age groups. In the low-fluoride areas the boys at 14, 15 and 16 years of age had DMF values of 10.6, 12.6, and 13.9 and the girls 12.0, 13.8 and 14.3. These values were distributed among decayed, missing, and filled teeth, as shown in figure 82. The girls generally had more filled and missing teeth, indicating more dental care. By age 16 the girls had lost an average of 1.6 and the boys 0.9 teeth. The sex difference in caries experience was probably not due altogether to the earlier age of eruption of the teeth in the girls. In the fluoride areas the 16-year-old boys and girls had lost only 0.3 and 0.4 teeth respectively. Need for dental care was obvious in 95 per cent of the children in the low-fluoride and 77 per cent in the fluoride areas (fig. 82).

The investigators closed their report of this monumental study with the statement that the incidence of caries in the children who had lived all their lives in the low-fluoride areas exceeded that of children studied in most other surveys and that further studies are needed to discover causes for the high accumulated caries attack rates of children living in Idaho, Montana, Oregon, Utah, and Washington.

### Dental caries in other regions.

The only other records of dental caries incidence included in these cooperative researches were those made in the Iowa-Kansas-Ohio study of 9- to 11-year-old school children, in a Rhode Island experiment with dietary supplements for 17 children and adolescents, and, incidentally, in a few other surveys.

Among 219 children in an Iowa school only 4 per cent were found to have teeth and gums in a healthy condition. Ninety per cent had one or more cavities and 43 per cent moderately diseased gums. Of 190 children in a Kansas school, 15 per cent had no cavities, 73 per cent had from 1 to 9 cavities, 12 per cent more than 10 cavities, and 5 per cent had diseased gums. In the Ohio school, 3 of the 53 children examined had no carious surfaces, half had 6 or more, and 14 had 10 or more.

The incidence of these defects in the three schools is not directly comparable because different methods of measurement were used, DMF in Iowa, open cavities in Kansas, and carious surfaces in Ohio. When allowances are made for these differences, the caries rates in the three schools are seen to be quite similar. Caries was considered the chief physical defect in the children.

In the extensive Louisiana nutritional status study on 8- to 11-year-old children, 56 per cent were found to have one or more carious teeth, 46 per cent had one or more filled teeth, and 36 per cent had one or more missing teeth. However, these figures include both deciduous and permanent teeth and the former may have accounted for most of the missing teeth. In the similar study in Virginia over 50 per cent of both white and negro children had carious teeth, 49 per cent of the white and 12 per cent of the negro children had filled teeth, and 47 per cent of the whole group had missing teeth.

In the Rhode Island study, 17 children of school age were examined as to blood composition, dietary intake, body measurements, skin and tongue signs of possible deficiency, and especially condition of the gums and teeth. A team of two dentists made all the mouth examinations. The examination was repeated at 6-month intervals for two and one-half years. After the first 18 months the children were divided into two groups, to one of which a tablet of 100 mg ascorbic acid was given daily and to the other a placebo, that is, a harmless dummy capsule. After 6 and 12 months the examinations were repeated.

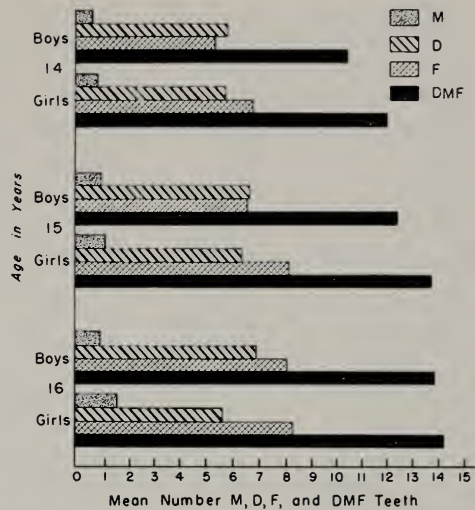



**Fig. 82. Mean number (without radiographs) of decayed teeth (D), of missing teeth (M), of filled teeth (F), and of decayed, missing, and filled teeth (DMF) for children in areas with 0.0 to 0.3 ppm fluoride in the municipal water supplies, classified by age and sex.**

Redness, swelling, thickening, bleeding, and retraction of the gums occurred in about half the subjects and were not perceptibly affected by the supplements. The average number of decayed, missing, and filled teeth was 2.5 at the beginning and 3.3 after two years and showed no relationship to the ascorbic acid supplementation.

The nutrient intake of almost all the subjects was inadequate in some respects, especially in calcium, iron, thiamine, niacin, and ascorbic acid. In the group receiving the placebo none had sufficient ascorbic acid. Their blood serum reflected this in that the ascorbic acid level was significantly lower throughout the supplementary period than that of the group which received the ascorbic acid tablet. The other blood values were not affected by the supplement nor were there initial differences between the groups. However, before the supplementation began, all these children had been found for 18 months to maintain good or excellent levels of serum ascorbic acid, from 0.98 to 1.58 milligram-per cent. Perhaps this good ascorbic acid status to begin with may account for the lack of effect of the supplement on the condition of gums and teeth.

The New Mexico study of high school children in Las Vegas revealed that the rate of dental caries was unusually low. The mean DMF of the Spanish-American group was 1.9, of the Anglos 4.7. The water supply contained only a trace of fluoride. The greater consumption of soft drinks and candy by the Anglos may account for their higher DMF rate. A statewide follow-up on this study may provide an explanation.

The Arizona study of Papago Indian children also revealed some differences in occurrence of gingivitis between the children attending an Indian Service school which provided a good lunch and those attending a private school which provided a smaller, less adequate lunch. Only 16 per cent of the former group had unhealthy gums, 81 per cent of the latter. The mean blood ascorbic acid levels of the two groups were 0.87 and 0.99 mg-per cent for boys and girls respectively at the Indian Service school, and 0.39 and 0.59 mg-per cent at the private school.

The following generalizations might be ventured as a summary of these researches: 1) The fluoride content of the water supply from 0.5 to 1.5 ppm has a striking protective action against caries for children who receive such water all their lives. 2) Freedom from caries is not achieved except by a small percentage of children, average 13 per cent, even with the optimum fluoride content in the water. 3) Direct effect of any nutrients is not apparent. 4) Hardness of the water or some element, not fluorine, exerts a small but perceptible reduction in the incidence of caries. 5) Caries is the most prevalent physical defect in American school children, increasing regularly from the youngest age through adolescence. 6) Ascorbic acid intake affects crucially the condition of the gums of children who are on the borderline of adequacy but cannot produce measurable improvement in groups already in good vitamin C status.

## BONE DENSITY

A reliable method of assaying the calcium status of the individual has long been sought. Since most of the calcium of the body is present in the bones, some measure of bone density might serve this purpose. A method of tracing the depth of X-ray shadows was developed at the Pennsylvania station in the hope of assessing the amount of calcification of the bones of living subjects. Bone density was evaluated by this microphotometric scanning procedure on the assumption that the density of the shadow is related in a known manner to density of mineral deposit in the bone and that through the use of a tiny ladder of ivory or alloy, photographed on the same film with the bone, corrections can be applied for any errors in exposure and development technique.

Some difficulties arose in that the soft tissue surrounding the bone also has density and this appears to be highly variable. When two X-rays of the heel or hand were taken at different angles, the density of the soft tissue could be calculated separately from that of the bone. When only one film was used, as sometimes occured, only the combined density was measured. However, a correction factor


**Standard film location for** phalanx 5-2 **bone density determinations.**

was developed for tentative calculation of bone density only for these cases.

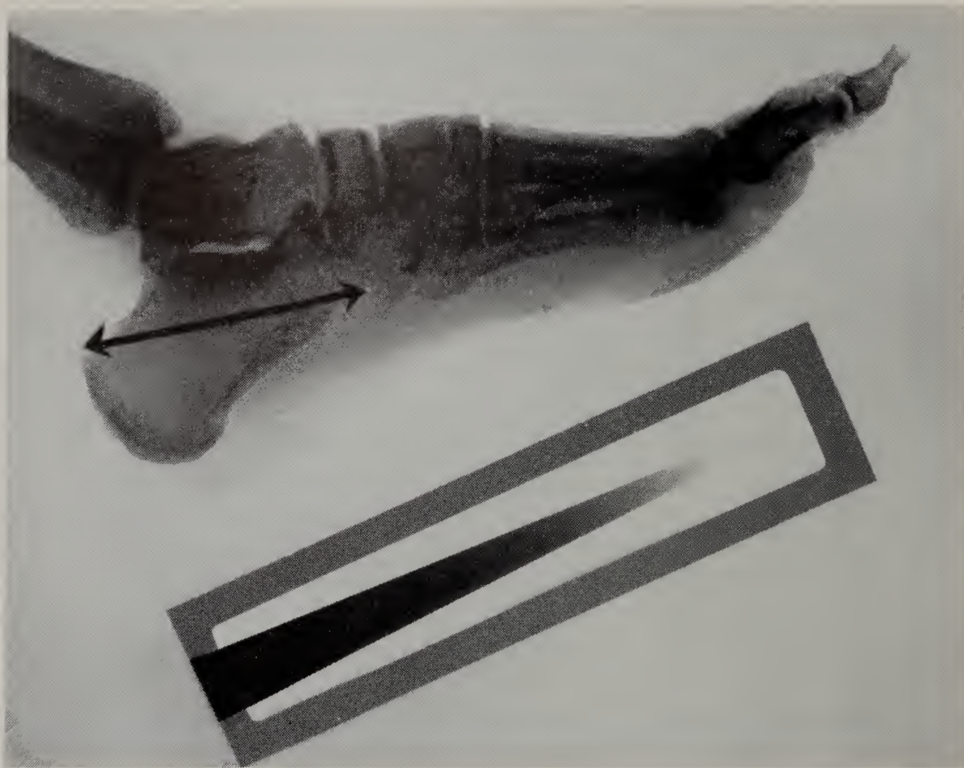
Another correction factor was also developed so that the readings against the ivory ladder used in the early surveys cauld be evaluated in terms of the metal ladder used in the later years of the Western study.

The two photos indicate the position of foot and hand and the standard film locations for the bone density determinationrs. Note the shadow of the ladder stardard.

The Western region included this X-ray procedure in all its nutritional status studies. Radiographs of heel and little finger, along with the ivory or alloy ladder, were taken and sent to the Pennsylvania station for tracing. Nearly 2,000 subjects of both sexes, ranging in age from 5 to past 80 years of age, were examined.

In figure 83, the average density of the *os calcis,* the heel bone, for males and females of this age range is shown, as well as similar curves for the density of the ends and centers of the little finger bones, phalanx 5-2. These densities were corrected for soft tissue.

It seemed clear that there was little change in the density of the heel bone with age and that there was some differ-



**Standard film location for** os calcis **bone density determinations.**

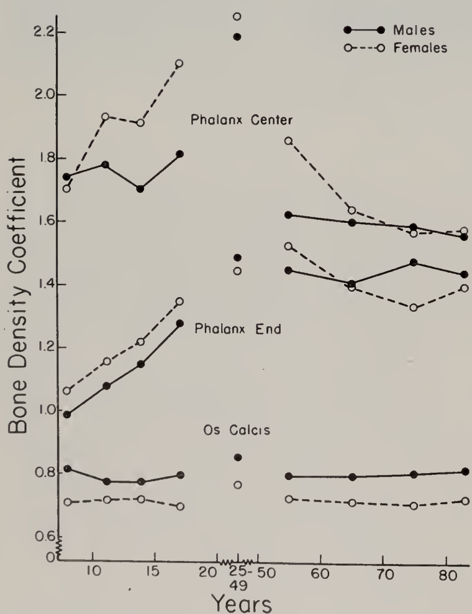



**Fig. 83. Average density of the** os calsis **and little finger bones for males and females.**

ence due to sex. At all ages this bone showed greater density in the males. The density of the finger bones was much more variable and was affected by both age and sex (figs. 84 and 85).

The developemental patterns of the bones studied were individual and were more variable in the females than in the males. In the growing years the girls nearly always had higher densities in both phalanx center and end than did the boys, but after age 60 the differences were not significant. Thus, rapid increase in density of the phalanx center in girls was followed by a rather sharp decrease after age 50, but these changes were much less abrupt and regular in the males. On the other hand, a smooth rise in the density of the phalanx end took place in both the boys and girls and a fairly regular decline in both sexes after age 50.

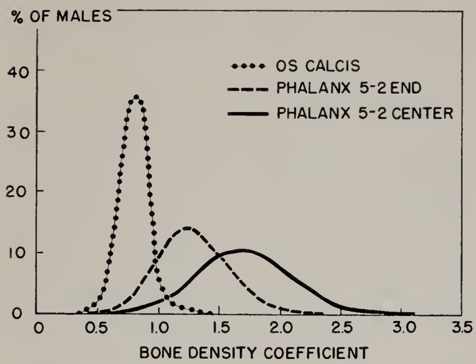



**Fig. 84. Frequency distributions of** os calsis, **phalanx 5-2 center, and phalanx 5-2 end bone density coefficients for males.**

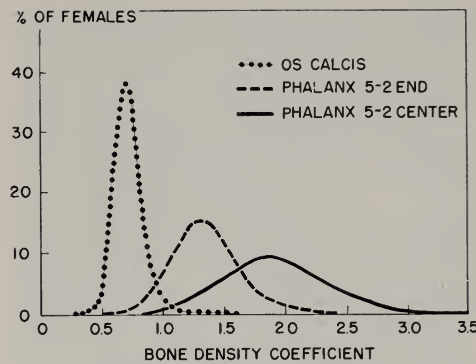



**Fig. 85. Frequency distributions of** os calsis, **phalanx 5-2 center, and phalanx 5-2 end bone density coefficients for females.**

The *os calcis* had the lowest density at all ages and in both sexes, the density of the phalanx end was intermediate, and that of the phalanx center the highest. The differences in densities of the phalanx centers and ends decreased significantly in the older age group.

Much study was expended on the possible correlation of nutrient intakes with these bone densities, but with no positive results except in the case of the Papago Indians in Arizona, previously discussed. The girls of this group, who had an ample school lunch at a public school, had greater densities of all three bone sites studied than did the girls at a private school, who had a small, inadequate lunch. This difference was not evident in the boys, and the sex difference in favor of the girls for both phalanx center and end, which was shown by the public school children, was not present in the private school group. It may be noted that the bone densities must be the result of the accumulated nutritional history of the individual, whereas the 7-day diet records used in these comparisons showed only the current food habits (fig. 74, School Lunches).

The food habits of the two groups of adolescent children, Anglos and Spanish Americans, studied in New Mexico were quite different, as previously described, but the bone densities were not significantly different for either boys or girls. Likewise, no differences were detected in bone densities of the children in Montana in two areas, one with no fluorides in the water and the other with 1 ppm (part per million), although there was a great difference in the rate of dental caries. A similar report was made by the Idaho station.

An experimental approach to the bone density problem was made at the Tennessee station. Here, young adults, mostly female, were the subjects of two series of observations of the heel bone. The results were not corrected for density of the sofe tissue but were expressed as density of bone plus soft tissue. X-rays were taken and 7-day diet records kept, then 4-day calcium balances were obtained, that is, intake and output of calcium measured. Then additional milk was given the subjects so that all calcium intakes were 1.0 gm per day or more. After three months on this milk-supplemented diet, X-rays were again taken and another balance obtained. Altogether, 20 subjects were observed. The calcium balances were low or negative in the subjects with low intakes but were usually corrected by the milk supplement. The bone densities, however, were not changed by the 3-month increase in milk intake.

Taking X-ray for bone density at the University of Idaho.

In the second experiment, the diets were self-chosen, calcium-restricted, mineral-vitamin-supplemented and milk-supplemented, successively. Negative balances, that is, calcium loss, occurred in all subjects in the restricted diet period, practical equilibrium in the mineral-vitamin-supplemented period, and positive gains during the milk-supplemented period. The larger, taller women had lower calcium retentions and also lower bone densities than the smaller or medium-sized subjects. It would appear that the former had a greater need for calcium. No changes in bone density due to the calcium or milk supplements could be seen. It was concluded again that bone density is the result of a long-term process but that changes cannot be produced in it by changes in diet over a few months.

A further experiment using white rats as subjects was undertaken. Young rats were put on diets of calcium content varying from 0.1 to 0.5 per cent, and both the calcium content of the body and bone density of the 9th caudal vertebra were seen to increase with increasing calcium intake up to 0.5 per cent calcium in the diet. Young adult rats were treated similarly for 9 months but significant differences in bone density were not achieved. By the use of radioactive calcium, it was determined that increased intakes of calcium in mature rats and controlled intakes in growing rats resulted in a probable increase in calcium storage, as indicated by decrease in the specific radioactivity of the bones and carcass. Nevertheless, the increases in the mature animals were insufficient to produce any change in the bone densities.

The full interpretation of bone density studies of this type remains to be achieved. The wide diversity of development and maintenance of the mineral content of the various bones studied makes it difficult to assess even so marked a pathological change as osteoporosis, or thinning of bone, especially of the vertebrae, in the aged with the density of other skeletal bones.

A full range of normal values remains to be established for bone densities for both sexes and for the life cycle. The Western group made a notable contribution to this end.

## AMINO ACIDS AND PROTEIN REQUIREMENTS

Most of the work on nitrogen balance, that is, intake and excretion of the characteristic element of proteins, was done by the Michigan, Missouri and Iowa stations and the amino acid studies by Wisconsin, Indiana and Nebraska. The first three stations collected and analyzed composite samples of the food intake and the excreta of 18 normal women, 33 to 77 years old during 27 periods of 5 days each on self-selected diets. The Indiana station determined the content of seven amino acids in these diets. The amounts of these seven essential amino acids in the self-selected diets of the subjects were found to be adequate according to the limits set up by extensive previous studies of young men at the University of Illinois. The limiting amino acid was methionine, a sulfur-containing compound, which was present in the diets in less than the recommended or even the minimal amounts. The Wisconsin station studied similarly four women 31 to 42 years old. The findings were similar for 10 amino acids of which methionine was again found to be in limited supply. As explanation of negative nitrogen balances observed the effect of low-calorie diets and poor distribution of protein among the meals was suggested by these investigators.

These same stations, in cooperation with the Bureau of Human Nutrition and Home Economics, conducted balance studies on 136 women over 30 years of age for 7- to 10-day periods on their self-selected diets. On the average, nitrogen retention was not achieved unless at least 1800 calories daily were consumed, and the amounts of protein required for equilibrium were calculated to be 66 to

**An Illinois technician determines the protein content of a food by the Kjeldahl method.**

**Measuring a composite sample of a diet for analysis.**

70 gms up to age 69 and 59 gms after age 70. More than a third of these women were significantly overweight.

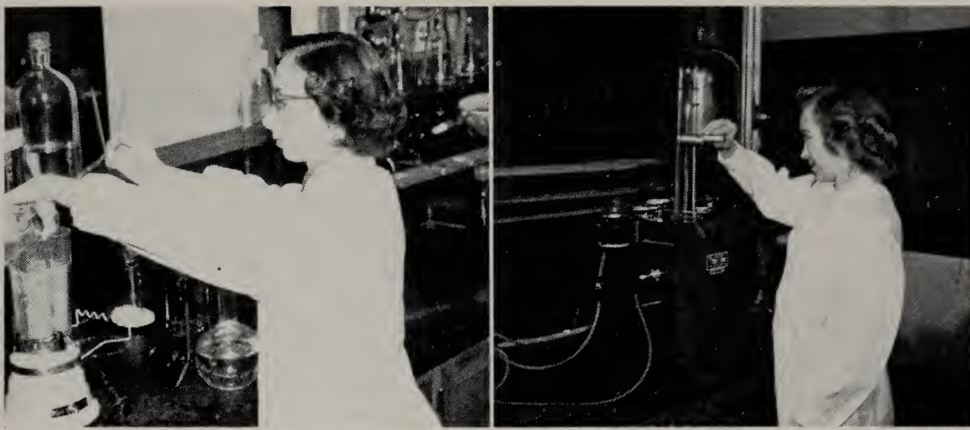
The calcium balances were largely negative unless about 0.9 gm per day was ingested. The youngest group, 30 to 39 years of age, and the oldest, past 70, tended to excrete less calcium in the urine than those in the 40- to 69-year range, an observation which was interpreted as indicating stress in the middle-aged group, possibly due to endocrine and menopausal changes. The higher protein requirement of these women for balance was also thought to be evidence of stress. Only after age 70 did the calcium needed for equilibrium decrease, from about 0.9 to 0.73 gm.

The phosphorus balance followed much the same pattern. Again, the negative balances were large in the ages 40 to 69 years. The amounts in the food required for balance were calculated as 1.25 to 1.51 gm phosphorus per day up to age 70, and 1.13 gm thereafter.

The many negative balances of nitrogen. calcium, and phosphorus registered by these women, some of them on apparently adequate intakes, point to long-continued nutritional losses not easily diagnosed and certainly not without their eventual toll in health and life. Ill-advised reduction of calories by the overweight women in this sample produced depletion of essential nutrients, exemplified here by protein, calcium, and phosphorus.

A further research on 11 women, 30 to 42 years of age, and one woman of 64 at the Wisconsin station combined amino acid analysis of the self-selected diets with nitrogen balances. In 15 of the 28 five-day balance periods there was loss of nitrogen from the body and this was definitely related to the calorie intake. Only when the total intakes were 30 calories or more per kg, about 14 per lb., of body weight, was nitrogen balance attained. All the essential amino acids except methionine were present in the diets in amounts equal to or in excess of

Young men subjects of the Illinois study of amino acid requirements eat their restricted diet.



**An Iowa laboratory assistant works with metabolic collections and (right) a research worker in Missouri determines energy value of a diet in the bomb calorimeter.**

the minima found necessary for maintenance of nitrogen balance in young men by W. C. Rose of Illinois.

A further study was done in this laboratory with 21 women subjects on semi-synthetic diets suplemented by various amounts of the amino acids, methionine and cystine. Cystine as well as methionine contains the element sulfur and has long been known to serve as a partial substitute for methionine. The minimal requirement for methionine for young men was set at 1.1 gm on a diet containing no cystine. When 0.5 gm cystine was given the women subjects at Wisconsin, four out of seven could maintain nitrogen storage, and the other three nitrogen equilibrium, on daily intakes of 0.15 to 0.18 gm methionine. On 0.29 gm methionine and 0.5 gm cystine all 13 subjects studied were in balance. With only 10 mg cystine and 0.29 gm methionine the diet was on the borderline of adequacy. But 0.26 gm cystine and 0.29 gm methionine was ample for nitrogen balance in all the six women studied. This was an important adjustment of the methionine requirement set up by the earlier work with young men, since it allowed a fairer evaluation of food proteins, which are often well endowed with cystine even though marginal in methionine. It also indicated that the methionine deficiency reported in the self-selected diets of women by the cooperating stations was probably only apparent, since all the diets contained more than the required 0.55 gm combined cystine and methionine.

Women subjects on semi-synthetic diets were also studied in the Wisconsin laboratory for minimal lysine requirements. About 95 per cent of the nitrogen was furnished by pure amino acids and an ammonium salt. Since the amino acid lysine occurs in foods of plant origin, such as cereals, in relatively low concentration, knowledge of the requirement is of importance. When 0.4 to 0.5 gm lysine was given daily, these 14 women were able to maintain nitrogen balance. This is about the amount determined to be necessary for young men. The average diet of even the lowest income groups in this country contains about 4 gm of lysine. The self-selected diets of the North Central women previously examined contained 1.7 to 8.6 gms lysine daily. It is interesting to note that height, body weight, body surface area, or age had no effect on the lysine requirement of the women. Apparently no sex differential exists.

The Indiana group also studied the lysine requirement of both young men and young women. The diet supplied about half the nitrogen, 9 gm daily total, from wheat and corn and the rest as purified amino acids and an ammonium salt. The cereals supplied about 0.5 gm lysine. When the cereals were supplemented by lysine all subjects were in balance with total intakes of lysine that varied from 0.5 to 0.8 gm. Only 3 of the 10 subjects needed more than 0.7 gm lysine and there was no difference between the men and women subjects. These figures are 0.1 and 0.2 gm more than were found with pure amino acids only. This is further reassurance that even on a cereal-containing diet the lysine need can be met rather readily.

The Nebraska station also used cereals in the diet as well as purified amino acids in a study of seven young women subjects. Apparently a combination of the bound amino acids in the cereal proteins and the free purified amino acids is well utilized and may be taken in varying proportions. Valine, one of the essential amino acids studied by this method, was found to be as well utilized in corn as in the purified form. The nitrogen balance was maintained on intakes of 0.23 to 0.53 gm daily as compared with the 0.65 gm minimum previously established by a slightly different procedure with young women subjects and 0.8 gm with young men. This type of experiment is necessary in order to translate the minimum amino acid requirements into terms of everyday foods. In some cases the naturally occurring, bound amino acid may be less fully available than the purified form used in the original requirement experiments.

The Alabama station studied the urinary excretion of tryptophan, another essential amino acid, when varying amounts and kinds of proteins were eaten. The amounts excreted in the various forms in 2- or 3-week periods by 12 young women were remarkably constant regardless of the amount or kind of protein in the diet and of the weight, surface area, basal metabolism, or urine volume of the subjects.

**The protein need of children.**

In pursuance of the study of the needs of preadolescent children set up in the South, the Louisiana group established the protein requirements of six girls, five of whom were 8 to 9 years old and one 11 years old. Natural diets were used, which provided about 62 gm protein daily for 56 days. No animal protein was given at breakfast in six of the eight periods and fat-free milk during the other two periods. The intestinal absorption of the dietary nitrogen was 92 to 95 per cent, and the total nitrogen output was 82 per cent of the intake. The 8- to 9-year-old girls retained 1.93 gm nitrogen or 19 per cent of the intake, the older girl 1.64 gm and about 14 per cent of the intake. There was no difference in retention caused by the omission of animal protein at the breakfast meal. Better nitrogen utilization had been reported in young women by the Nebraska station when some animal protein was included in each meal instead of being concentrated in the noon or evening meal. However, this was not the case with these young girls.

Whether the retentions were compared with intakes per kilogram body weight or per square meter of body surface, the correlations were the same, indicating that requirements may equally well be stated either way. These children had good nitrogen retentions on intakes of mixed proteins providing almost exactly one gram of protein per pound of body weight per day.

**The heat production caused by high- and low-protein diets.**

It has long been taught by nutritionists that high-protein diets cause more heat to be eliminated by the body than do low-protein diets. Protein fed alone may increase the metabolism by 30 to 40 per cent of the energy of the protein fed, the corresponding values for carbohydrate and fat being about 5 per cent and 4 per cent, respectively. Ordinarily the total dynamic effect of all together amounts to about 6 per cent of the basal metabolic rate.

The Pennsylvania station reinvestigated this subject, with 18 young men who were given diets alternately high and low in protein, that is, containing either 6 or about 20 per cent of the calories as protein The resting metabolism was measured by the analysis of expired air collected in a Tissot spirometer at intervals throughout the day. The heat production from the diet higher in protein was found to be about 5 per cent higher than from the diet low in protein.

In another study, using the respiration calorimeter, the 24-hour metabolism of four subjects was measured by both direct measurement of the heat given off and indirect measurement by the nitrogen-carbon-energy balance method. Close agreement between these methods was obtained. The periods of observation varied from two to three weeks, with each subject acting as his own control, going from low- to high- and high- to low-protein diets in alternating periods. The measurements of heat production were made while the subjects were physically at rest and relaxed. When these 24-hour periods of observation were compared, the heat production on the high-protein diet was found to be about 8 per cent above that on the low-protein diet.

Later measurements indicated that the heat production of one pair of subjects was 5 per cent higher on the high- than on the low-protein diet, but no difference due to protein intake was seen in the other pair.

These results indicate smaller differences in calorie output due to high-protein diets than were seen in the early metabolism studies in Germany and this country. The difference may probably be ascribed to the short adaptation periods allowed in the earlier studies and to the use of meals of protein alone rather than to natural diets containing various amounts of protein. This points to the importance of adaptation or "getting used to" drastic changes in diet, as, for example, in reducing regimes.

## VITAMIN C NEEDS OF CHILDREN AND ADULTS

The vitamin C status of children and adults was investigated by one or more stations in all four regions. Three of the studies were made on children, in Iowa, Louisiana, and Washington, seven on adults, mostly female, at the Connecticut (Storrs) and New York (Cornell) stations, one on older women in the North Central region, and one on older men and women in California.

### The Iowa children.

The Iowa station found a wide variation in both the intakes of ascorbic acid by children and its concentration in their blood serum. About 650 boys and girls 6 to 18 years of age in 44 schools in town and country were studied.

The average total ascorbic acid content of the food increased with age in the boys from 71 to 100 mg per day, but the serum level fell at the same time from 0.86 to 0.54 mg-per cent. These average intakes were equal to or above the recommended allowances, yet the average blood levels fell below those generally accepted as desirable. The same changes occurred in the girls, practically constant intakes from 6 to 15 years of age but sharply declining blood levels, followed by some rise in blood levels in the 16-, 17- and 18-year-old girls. About one-fourth of the Iowa children had serum levels below 0.4 mg-per cent, a poor rating.

If the intakes are expressed as mg per kg of body weight, a consistent decline occurred in the diets of both boys and girls, from 3.5 to below 1.5, paralleling the decline in serum ascorbic acid concentration, but the rise in the serum level of the girls after age 15 becomes even more striking (fig. 86). Possibly a similar change with maturity may take place in the boys as well but beyond age 17. However, in this study there were only ten boys over 17 and they showed no upturn in ascorbic acid levels.

There was a positive correlation between intakes and blood levels, especially when the intakes were expressed as mg per kg body weight. When the ascorbic acid of only the vitamin C-rich fruits and vegetables was compared with the serum levels, the correlations were just as good as when the total ascorbic acid of the diet was used. The vitamin C-rich fruits and vegetables were tomatoes, citrus fruit, some berries, cantaloupes, and raw cabbage. Other foods obviously contributed but little ascorbic acid to the diet.

On the whole, the older children were in poorer condition so far as blood ascorbic acid went than the younger ones; about 50 per cent more over 12 years of age were judged only fair or poor, that is, with blood levels 0.6 mg-per cent or less, as compared with those under 12 years. This may mean that the endocrine stress of puberty raises the need for ascorbic acid for both boys and girls during the teen years, but the girls rebound from this stress to maturity after age 15. The age of such rebound, if it occurs, in boys was not detected but it is probably beyond age 17 or 18.

**The Louisiana study.**

An earlier study of 552 Louisiana children 8 to 11 years old in six elementary schools of New Orleans and Baton Rouge yielded somewhat similar results. The

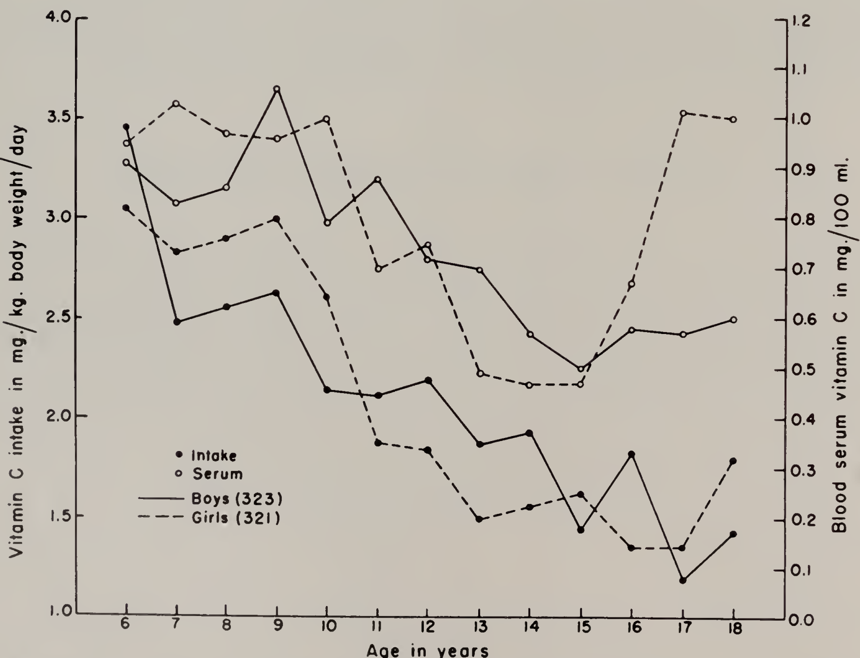



Fig. 86. Changes in mean intakes and mean serum concentrations of vitamin C with age for Iowa children sampled from 44 schools in 1949-1951, and for whom both serum values and dietary records were available.

mean blood ascorbic acid level of all the boys and girls was 0.7 mg-per cent, compared with 0.9 for the 128 Iowa children of this age group. The mean intake was 74 mg per day, compared with 77 mg for the Iowa children. The difference in current intake seems insufficient to account for the differences in blood levels. However, the usual significant correlation was found by the Louisiana workers between intake and blood levels. Linear correlation ceased at intakes above 110 mg and serum levels of 1.1 mg-per cent, doubtless because saturation was reached.

The condition of the gums of these children was recorded by a highly competent medical observer. Such changes as marginal redness, bleeding, swelling, atrophy of papillae, and recession were graded as 0, 1, 2, according to occurrence and severity, and compared with the blood levels of ascorbic acid. The number and severity of gum changes were found to be correlated with the blood levels. On the whole, the ascorbic acid status of these children was only borderline, since half the blood values were 0.6 mg-per cent or less and more than 40 per cent of the daily intakes were less than 60 mg.

Some of the children were examined in the spring and some in the autumn and winter. The blood levels observed in the fall were higher than in the spring, obviously because of intake of more fresh fruits and vegetables during the summer. Citrus fruit, strawberries, and raw tomatoes contributed 54 per cent of the ascorbic acid of the diets; other fruits, raw, cooked, and canned, 7 per cent; potatoes 9 per cent; all other vegetables 20 per cent, and milk about 11 per cent. The potatoes and milk, though insignificant usually as sources of vitamin C, were used in large enough quantities by these children, nearly 5 quarts of milk and 4 or 5 servings of potatoes per week. to make their contribution important.

**The Washington adolescents.**

The Washington station studied 248 boys and girls, 15 and 16 years old. Rather elaborate slit-lamp or biomicroscopic examinations of skin of the upper arm and of the gums were checked by colored photographs of these tissues, by dietary records, and by serum ascorbic acid determination. The intakes on the whole were moderate to low, 82 mg per day for the boys and 69 for the girls. As might be expected, the serum values were only fair, 0.67 mg-per cent for the boys and 0.79 for the girls. The difference between the levels for the boys and girls was significant. These blood values, however, compare favorably with those of the Iowa adolescents of the same age group, 0.54 mg-per cent for boys and 0.57 for girls. The intakes of the Iowa children were higher, 92 and 80 mg for boys and girls, respectively. As was true of the Iowa girls over 15 years of age, the Washington girls had higher blood levels with lower intakes than might have been expected.

The gum changes indicated a moderate amount of deficiency, generally more marked in the boys than in the girls, and more chronic than acute. Significant correlations between vitamin C intake, blood level, and gum changes were not established in this study, possibly because the gum changes represented long-standing conditions whereas the blood levels and intakes reflected only recent and current customs.

The use of the Kodachrome slides to confirm and preserve the observations on the gums appeared well justified. Similar conclusions were reached in the Northeastern region in the evaluation of photographic evidence.

**Women in a Connecticut institution.**

Three different groups of women 27 to 74 years old were the subjects in a study of the response of serum ascorbic acid level to gradually increasing levels of intake of the vitamin. On an intake of 45 mg ascorbic acid per day the blood levels fell in two months from 0.97 mg-per cent to 0.42, and in five months to 0.13. After one month on a 25 mg supplement, then one month on a 50 mg daily suplement of the pure vitamin, the serum level rose to 1.49 mg-per cent. On 100 mg daily no further rise occurred, possibly because the tissues were already saturated with the vitamin. This was indicated by the failure of urinary ascorbic acid excretion to rise above the usual 5 mg per day until after the month on 100 mg supplement, when the excretion was 30 mg. Urinary excretion during an 8-hour night was taken to be an indicator of surplus intake of the vitamin.

A second experiment with 19 women showed quite similar results. After seven weeks on a dietary intake of 33 mg without supplement, the blood levels fell to 0.47 mg-per cent, increased to 0.74 after five weeks on an added supplement of 25 mg, to 1.47 after five weeks on 50-mg suplement, and to 1.69 following five weeks on a 100-mg supplement, making a total daily intake of 133 mg. The ascorbic acid of the white blood cells, which is thought to represent the saturation of the tissues as the serum ascorbic acid represents the current intake and utilization, fluctuated much less, from about 30 to 20 mg-per cent on the low intake, then up to 27 and 35 mg-per cent on the larger supplements. On 133-mg daily intake on the average no further increase occurred (fig. 87). It was concluded that over a period of several months the ascorbic acid of the white blood cells and of the serum varied in nearly the same order and so the serum value might be a fair indication of that of the white blood cells and the tissues.

A third study concerned the effect of age on the utilization of ascorbic acid by women. Fifteen women, average age 31 years, had 0.33 mg-per cent in the serum after seven weeks on 32 mg daily intake of ascorbic acid and this rose to 1.76 mg-per cent when the intake was gradually raised to 107 mg. The concentration

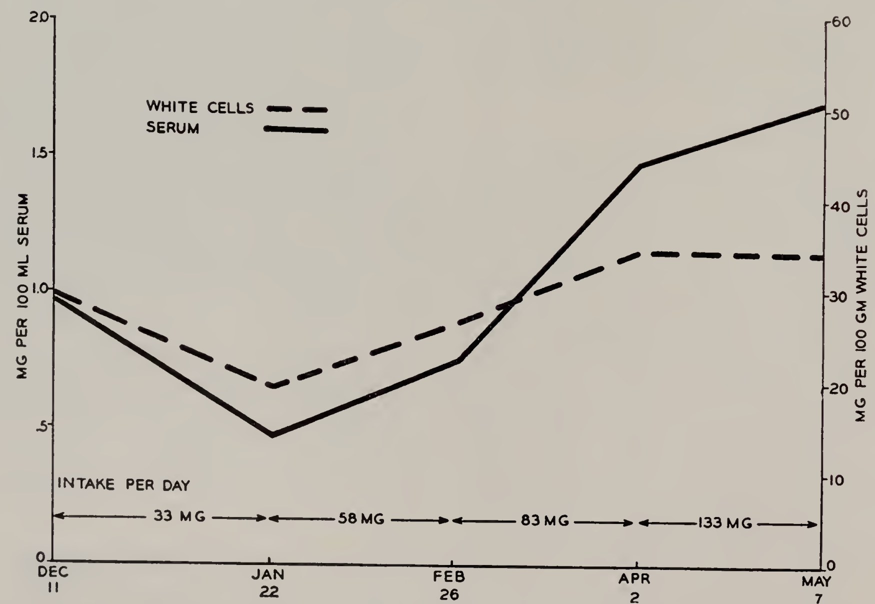



Fig. 87. Average values for ascorbic acid in blood serum and in white blood cells for 19 women receiving an average dietary intake of 33 mg ascorbic acid per day, with the following ascorbic acid supplementation: 25 mg from Jan. 22 to Feb. 26; 50 mg from Feb. 26 to Apr. 2; 100 mg from Apr. 2 to May 7.

of ascorbic acid in the white blood cells at the same time rose from 26 to 35 mg-per cent, the maximum at 57 mg intake. In 13 older women, average age 64 years, the serum ascorbic acid rose from 0.24 to 1.42 mg-per cent during the 10-week period, and the white blood cell level from 22 to 35 mg-per cent. The latter maximum value was not reached until the intake was 72 mg per day, as compared with 57 mg for the younger women. Correlation between serum and white blood cell ascorbic acid levels was significant only in the younger women on intakes of 32 and 47 mg ascorbic acid per day.

#### Young men and women at the New York Agricultural Experiment station.

At the New York station young men and women were the subjects, and the object was again to determine the effect of intake of vitamin C on the levels in blood serum and white blood cells. After 31 days on a diet containing only 7 mg ascorbic acid per day, the serum level fell to 0.3 mg-per cent, and the white blood cells to 13 mg-per cent, after 78 days to 0.2 and 11.5 mg-per cent. When the serum values were less than 0.4 mg-per cent only one white cell value was greater than 14 mg-per cent. With serum values over 0.4 mg-per cent, the white cells all had more than 14 mg-per cent. This would indicate that serum of 0.4 mg-per cent or less would indicate a past history of poor ascorbic acid status and an inadequate present intake. Values this low had been found in 18 to 44 per cent of boys 13 to 20 years old and 5 to 27 per cent of girls of the same age range in the Northeast nutritional status surveys.

Another study by these same methods involved 13 subjects, 10 men and 3 women. After a very low intake period of 78 days, each subject took in succession 20, 30 or 40 mg of ascorbic acid daily. After 7 to 11 days on 40 mg the serum and white blood cell levels of the vitamin were significantly higher than on 30 mg intake for 11 to 14 days. Even on 20 mg those with very low previous levels showed a rise in white blood cell values. This seemed to show that the ascorbic acid status of the subject previous to the supplementation may affect the rate of response—the greater the depletion, the better the response.

#### The Vermont study.

An interesting study of the effect of daily supplementation of the diet with 400 mg ascorbic acid on the condition of the gums of 49 young student nurses was carried on for three years. Colored photographs of the gums were taken in the spring and fall from the fall of 1952 to the spring of 1955. Three blood samples were analyzed for serum and white cell ascorbic acid, and 17-day diet records were secured each fall and spring. After the 1952 examination, the group was divided into test and control groups, the former receiving thereafter 400 mg ascorbic acid daily and the latter imitation tablets or placebos containing no ascorbic acid.

Pitting, color, bleeding, retraction, thickening, blunting, recession, and swelling of the gums were systematically evaluated from color transparenices, and any changes in two and one-half years evaluated. These signs were not changed by the ascorbic acid supplementation. There was no consistent difference in the severity of these signs, as noted at the end of the study, between the test and control groups. There was an immediate significant increase, however, in the concentration of ascorbic acid in both serum and white blood cells.

#### The Texas study.

At the Texas station, eight women and one man were the subjects for a prolonged study of the utilization of ascorbic acid. Five of the women were between 61 and 71 years of age, and three of the women and the man were between 26 and 38 years of age. A simple mixed diet adequate in all nutrients except for ascorbic acid was used in the five periods of 14 to 19 days each. The amount of ascorbic acid given daily in raw cabbage or as the synthetic vitamin was proportional to the body weight of the subjects, from 1.5 to 2.5 mg per kilogram per day, and the criterion of utilization was the level of ascorbic acid in the blood plasma. An effect of season on the utilization of the vitamin was noted, in that on the same intake the blood ascorbic acid levels in most of the subjects were significantly higher in the winter than in the summer. Higher environmental temperatures appeared to increase the need for this vitamin.

For most of the subjects, the ascorbic acid of raw cabage was as fully used as was that of the pure synthetic substance. When the group was given 1.5 and 2.5 mg per kg per day doses of the vitamin, the plasma ascorbic acid levels were always higher on the higher dosage. This confirms the findings of the Connecticut studies previously mentioned. In the Texas study, no clear difference in utilization of ascorbic acid could be ascribed to age, chiefly perhaps because of the variability of response by the subjects. A carefully

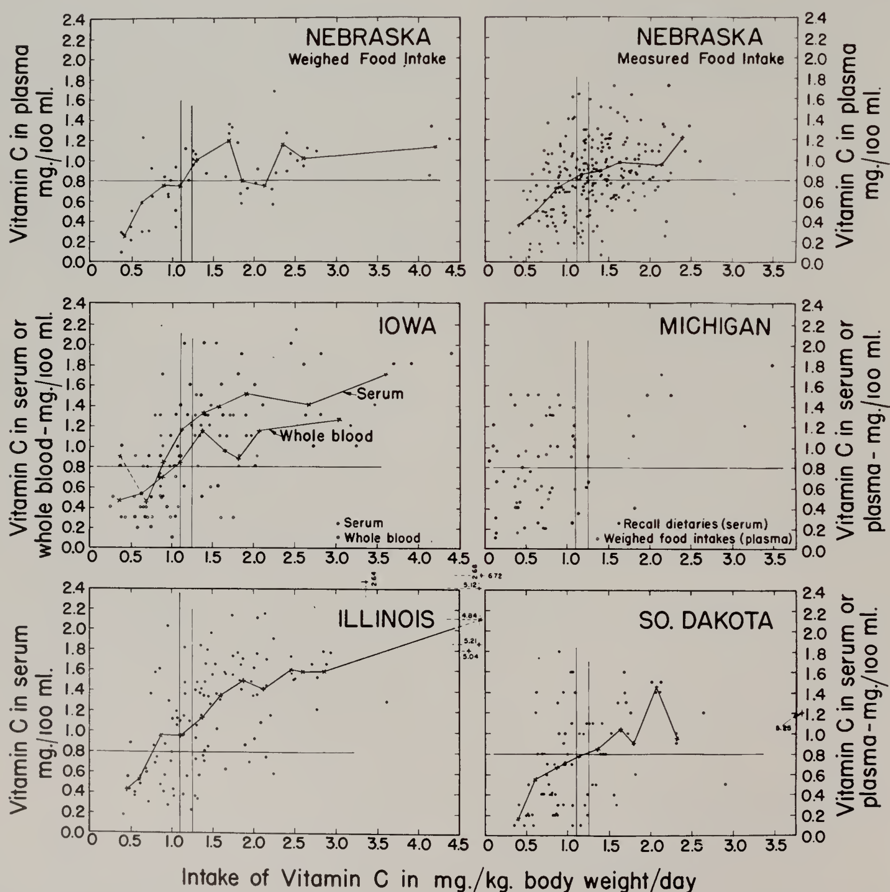



Fig. 88. Scattergrams of the vitamin C concentration in the blood of women in five locations in the North Central Region, plotted against intakes in mg per kg body weight per day. The lines represent the averages. Note good correlation in all cases.

controlled investigation of the age factor in the use of this vitamin by both older men and women is obviously needed.

### The North Central studies of women.

The five North Central stations used only women, 20 to 80 years of age. There were 596 women altogether, 68 of them studied in two periods. Seven-day records of self-selected diets were kept, blood samples were analyzed, and in 135 of the subjects urinary excretion of vitamin C was determined. The mean blood levels for the five states, Iowa, South Dakota, Michigan, Illinois, and Nebraska, varied from 0.76 to 1.20 mg-per cent in the various age decades, and the intakes from 60 to 104 mg per day. There was a direct relationship between intakes and blood levels but this was curvilinear rather than linear (fig. 88). Urinary excretions of vitamin C studied at the Iowa, Michigan, and South Dakota stations, whether before or after a dose of 400 mg of the vitamin had been given, showed a good deal of variation. When the daily intake exceeded 1.1 mg per kg body weight, the basal excretion was in nearly linear relationship to the intake. Beyond a usual intake of 1.25 mg per kg intake, the slope of the excretion of the extra 400 mg dose was less steep than at lower intakes (fig. 89). On less than 1.1 mg per kg per day intake, the blood levels were likely to be less than 0.8 mg-per cent, the basal urinary excretions less than 15 mg, and the extra dose or test-load excretions less than 115 mg. Intakes greater than 1.1 mg per kg per day resulted in higher values in these three parameters. When the Iowa subjects were classified into groups having more or less than 1.1 mg per kg intake per day, 71 per cent were found in two groups, those who had urine and blood figures above the expected figures and those with values below the expected figures. Of the remaining 29 per cent, one-half could not be so classified because of the blood

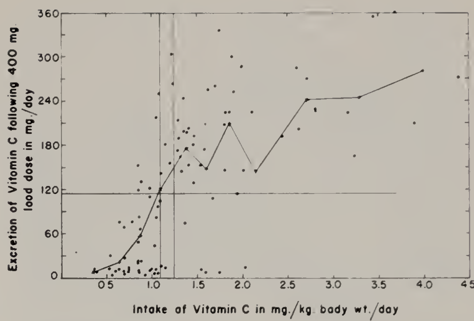



**Fig. 89. Urinary excretion of vitamin C during 24 hours after a dose of 400 mg ascrobic acid was given, plotted against the average daily intake of vitamin C by these women. Note fair correlation.**

value only. The South Dakota and Michigan subjects were less easily classifiable, possibly due to the greater average age, or the smaller number of subjects.

The conclusion was reached that age did not influence either the intake or the blood level of these women. The Iowa women were in ascorbic acid equilibrium with blood levels above 0.8 mg-per cent when the intake equalled or exceeded 1.1 mg per kg per day. This was accepted as a desirable minimum intake, 64 mg for the woman of average weight, 58 kg, comparable with the 70 mg of the 1958 recommended allowance.

### The California study of older men and women.

The last ascorbic acid study to be reported here was that done in California with 569 men and women over 50 years old. The self-selected diets of the 525 men and women living in their homes contained adequate mean amounts of ascorbic acid, 99 mg daily for the men and 86 for the women. In terms of body weight these values were 1.4 and 1.3 mg per kg and were not significantly different. There were 44 men over 60 years of age living in the County Home also included in this study. Their institution diet contained 40 mg per day, or 0.62 mg per kg body weight.

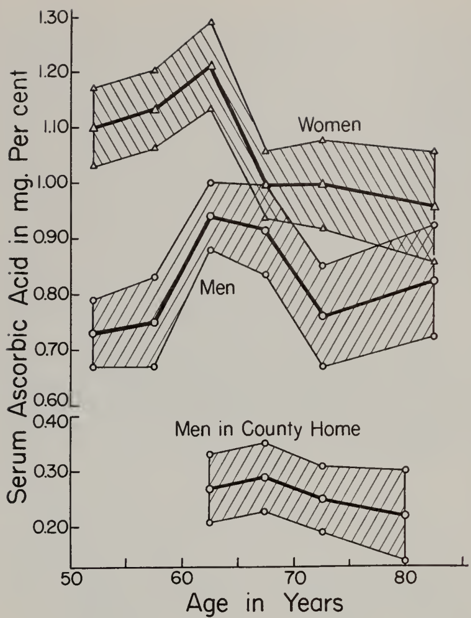



**Fig. 90. Mean blood serum vitamin C of California men and women, plotted against age. Note peaks at 62 years in both men and women, and extremely low values for men in the county home. The limits of statistical variation are shown in the barred areas.**

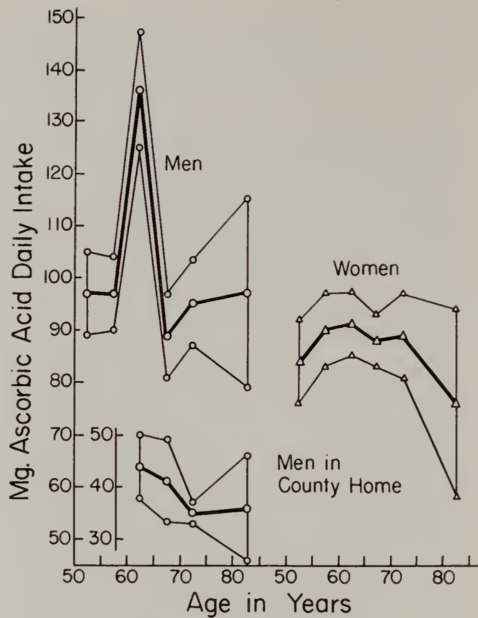



**Fig. 91. The mean daily intake of vitamin C of California men and women 50 to past 80 years of age. Note peak in both men and women at 62 years of age and very low intakes of men at the county home. The limits of standard error are indicated by the light lines.**

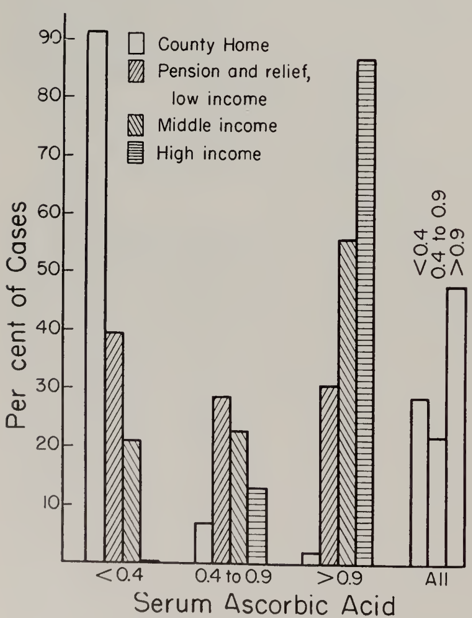



**Fig. 92. Variation of blood serum vitamin C with economic status.**

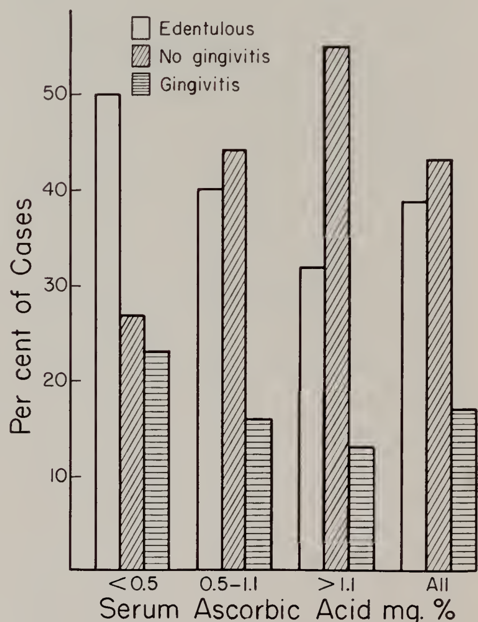



**Fig. 93. Increase in percentage of edentulous (toothless) persons, and in gingivitis (inflamed gums), with decrease in level of blood serum vitamin C.**

The blood levels of the men and women living at home were on the average 0.83 and 1.07 mg-per cent respectively, but that of the men in the County Home was only 0.27. The men at every age had lower blood levels than the women, even with equal or larger intakes. About a third of the men and a tenth of the women had blood levels of less that 0.4 mg-per cent. the "poor" rating. As shown in figure 90, a peak occurred in both sexes at about age 62; likewise, a peak of intake, followed by a dip, occurred at this age (fig. 91). The men in the County Home had extremely low intakes and blood levels at all ages. Whether intake or serum ascorbic acid levels were used as point of reference, the close correlation of one with the other was evident for both men and women.

The possible effect of adrenal and sex hormones on ascorbic acid nutriture was suggested by these results. The peak of serum ascorbic acid at about age 62 in both men and women may result from abrupt postmenopausal decrease in sex hormone production. Since ascorbic acid is in some undefined way related to production of these and the adrenal hormones, more of the vitamin may be released in the blood stream when hormone production is decreased. The same suggestion was made to explain the sustained high blood cholesterol levels of women past the menopause.

The general conclusion reached was that men over 50 may have a definitely higher ascorbic acid requirement than women.

An interesting relationship between economic level and blood ascorbic acid was noted (fig. 92). The men in the County Home, those on public assistance rolls, the large majority (70%) in the middle-income bracket, and the small number in the top-income group had levels of blood ascorbic acid increasing in that order. This difference was ascribed to education and food habits rather than to sheer buying power.

About 39 per cent of all these people were edentulous, that is, had no teeth, 17 per cent had marked or moderate gingivitis, and 43 per cent had relatively healthy mouths. More of the edentulous and those with gingivitis had low serum ascorbic acid levels than did those with teeth and no gingivitis (fig. 93). This accords with the general findings (fig. 73) that serum ascorbic acid has an inverse relationship to prevalence of gum and mouth signs of possible deficiency.

There emerges from these cooperative researches some indication of the greater need for vitamin C of males than females, at least after age 12. Both tissue content, as shown by the ascorbic acid level of the white blood cells, and circulating blood concentration reflect the intake of this vitamin, the tissues indicating the past history and the blood serum the recent custom. Changes during adolescence and menopause appear to exert stresses which affect the utilization of this vitamin and may increase the need for it in the diet. About a third of the men and boys and a somewhat smaller proportion of women and girls had blood levels indicating an unsatisfactory status as to ascorbic acid.

A great deal of interest has arisen in recent years in regard to the levels at which cholesterol and other lipids circulate in the blood. This is because of the suspicion that arteriosclerosis and heart damage may be associated with high levels of these substances, especially cholesterol, in the blood. The effect of fat in the diet has been studied in numerous efforts to determine why blood cholesterol is so much higher in Americans and North Europeans than in some other peoples, for example, Japanese, Italians, and Spanish. Likewise, incidence of deaths from arteriosclerotic disease is much greater among North Europeans and Americans than among the other peoples named. However, methods of diagnosis of this disease are undoubtedly different in the United States from those in some of these other countries.

The outstanding difference in the diets of all these peoples is in the quantity and quality of the fat. Americans obtain a high proportion of their calories from fat, 40 to 45 per cent, but Japanese, Italian, and Spanish laborers get only 20 per cent of their calories from fat and this is of vegetable origin. Present evidence indicates that fat in the diet is the single factor which most directly affects the serum cholesterol level. Fats and oils of vegetable origin, containing a high proportion of unsaturated fatty acids and especially of the highly unsaturated essential faty acids, tend to lower rather than to raise the serum cholesterol. Fats of animal origin, especially milk fat, have the opposite effect.

Can we then control incidence of coronary occlusion and similar serious circulatory diseases by controlling our fat intake? Is the dietary fat effect the same in men and in women? Coronary accidents are far more frequent in middle-aged men than in women, but with advancing age the sex difference tends to disappear. Does the level of cholesterol in the blood also follow this pattern, high in middle-aged men but not in women, equalized in the older age groups? Three of the regional groups undertook studies of serum cholesterol in older women and one also studied older men in the hope of adding a few facts to the mounting pile of evidence on this problem.

**Women in a Connecticut institution.** Twenty-nine women 28 to 77 years old, living in an institution, were studied for serum cholesterol while living on the regular institution diet exclusive of all high-vitamin-C foods. This was low in ascorbic acid content but was supplemented after seven weeks by increasing dosages of ascorbic acid, from 15 to 75 mg per day, each dose maintained for a two-week period. The mean serum cholesterol of the 15 young women (28 to 34 years old, agerage 31) was 172 mg-per cent, of the 14 older women (56 to 77 years, average 64) was 230. The diet was the same in both groups. Both the fat and cholesterol intakes averaged the same in the two groups. In both groups 34 per cent of the total calories was obtained from fat. As the serum ascorbic acid of both groups rose with the increasing supplements of ascorbic acid, no change occurred in the serum cholesterol of the young women, but a significant rise occurred in the older women. Such a rise in serum cholesterol has been observed when there is a rise in serum ascorbic acid. But in the young women this extra cholesterol may be utilized in the production of female sex hormone, which is chemically closely related to cholesterol. If the sex hormone is no longer elaborated in the older women, the extra cholesterol might be circulated in the blood. This had been suggested by the California investigations.

In any case, the investigators concluded that the difference in blood cholesterol between the two groups of women seemed to be due to age, with diet playing no part. However, the cholesterol levels found were low compared with all others reported for similar groups of women. Low cholesterol levels are characteristic of institutionalized people, both men and women.

**Iowa, Nebraska and Illinois women.** In the North Central region three studies on this subject were carried out. The Iowa and Nebraska stations combined a report on 54 women in Iowa and 130 in Nebraska, 18 to 92 years of age. There were from 18 to 51 women in each decade from 20 to 80 years. In figure 94 is shown the mean serum cholesterol value for these women. A steady rise was seen from age 20 to the seventh decade, average age 63.4 years, followed by a fall in the eighth decade. Basal metabolism, blood pressure, and weight were only slightly associated with this rise, which was ascribed to age. The diets used were typical of North Central custom, containing rather high contents of both protein and fat. The intake of both of these constituents of the diet declined with advancing age, but the average body weight increased up to average age 63. However, statistical calculations revealed no significant correlation of the serum cholesterol with any factor except age. A very large number of cholesterol determinations on the blood of mid-Western men, who undoubtedly consumed diets quite similar to those of the women in this study, had shown a similar rise with age but with the peak about 10 years earlier, at 55 years. The fat in the diet of these men had been rather convincingly shown to be positively correlated with their serum cholesterol levels. The cholesterol values for these Iowa and Nebraska women were lower at all ages than those found in the

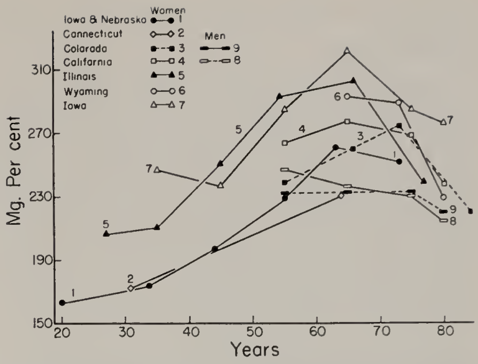



**Fig. 94. Mean serum cholesterol of men and women from 20 to past 80 years of age in three regions. Note peak in the mid-sixties for all the women except the Colorado group, with peak in the seventies. No peak in the records of the men.**

other cooperative researches and, indeed, lower than any reported for women living at home.

The Illinois station studied serum cholesterol in 113 women from 26 to 92 years of age. Only nine were more than 70 years old. Again, a steady rise in cholesterol with advancing age was found (fig. 94) to a maximum of 302 mg-per cent at 65.8 years of age. Practically the same level, however, was observed at 54.2 years. The group beyond 70 years, mean age 77.2, showed an abrupt decline to 249 mg-per cent. All these levels are much higher than those found by the Iowa and Nebraska workers, although the diets, age, and other characteristics of the subjects were similar. No correlation was found between serum cholesterol levels and blood pressure, percentage of calories from fat or protein in the diets (39 and 16 per cent, respectively), or energy value of the diet. Positive correlations were found between serum cholesterol and body weight as well as age. Body weight expressed as pounds per inch increased from 2.02 at age 37 to 2.56 at age 57, then slowly declined. Most of the rise in cholesterol, however, was ascribed to age only. However, the number of subjects in the various age groups was rather small for the establishment of valid correlations.

Another report came from Iowa on a study of 58 women 30 to 90 years old. The main question raised was as to the rate and completeness of absorption of fat by the older women, but cholesterol levels were also measured. The minute particles of fat, chylomicrons, which enter the blood stream during absorption of a meal of fat, reached a peak of concentration in the blood of older women later than in young adult women. The usual peak time is 2 to 4 hours after a fat meal, with return to resting value at a fairly rapid rate. In the older women the peak was reached after 4 to 6 hours, in the younger women after 1 to 3 hours. With every additional decade the peak was delayed about 1 hour. Also, the longer it took for the peak to be reached, the greater was the count of chylomicrons in the blood. Thus it appears that with advancing age the pattern of fat absorption is changed and fat utilization delayed. If the presence of a high concentration of fat in the blood for long periods is harmful, as some medical investigators have claimed, then high fat diets may not be safe for old people.

The serum choleseterol of these women rose from the younger to the older age groups in much the same fashion seen by the Illinois investigators (fig. 94). The highest cholesterol concentration again was found in the seventh decade, at 60 to 69 years of age, with a sharp drop thereafter. However, no significant relationship was found between chylomicron count and serum cholesterol, indicating that serum cholesterol level may not be dependent upon the pattern of fat absorption.

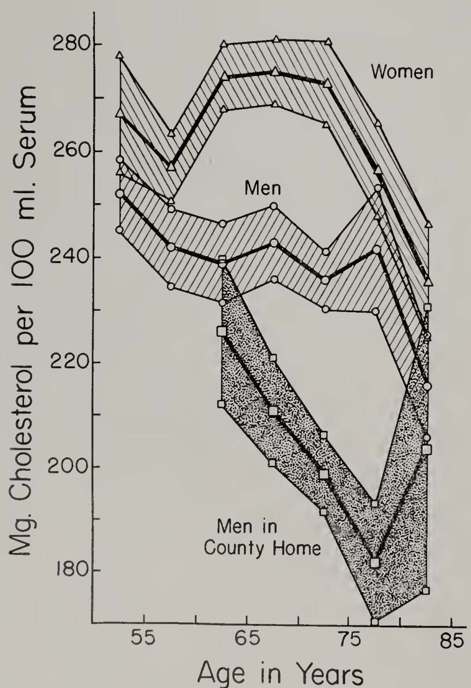



Fig. 95. Changes with age in serum cholesterol levels of California men and women living in their own homes, and men in the county home. The area of standard error is marked.

**The California study of women and men.** The California station studied the serum cholesterol in 577 men and women past 50 years of age and on diets of known composition. The women at every age had higher serum cholesterol than the men, even on diets of like composition. The serum level was found to be significantly related to both the fat and the cholesterol of the diet, but the sex difference held even when these components were present in larger amounts in the diets eaten by the men (fig. 95). The levels attained by the women at various ages were somewhat lower than those reported by Iowa and Illinois but higher than those found in the Iowa-Nebraska study. Again the average peak value occurred in the age period 60 to 69 years, but the figures changed very little in the 20 years from 50 to 70 The fat content of the diets of these California women was lower, 36 per cent of calories, than that of the North Central women, 42-44 per cent of calories.

The contrast with the values for men of the same ages was striking. The highest value for the men was found in the 50- to

59-year-old group, followed by a smooth decrease in every decade thereafter.

**The men in the County Home.** A special group of 50 men who lived in the County Home presented an interesting contrast. Their blood cholesterol levels were strikingly lower at every age than those of the men living in their own homes. Their diets were much lower in both fat and cholesterol as well as in vitamin A, carotene, and ascorbic acid, than the diets of men living at home. This is another example of the occurrence of low cholesterol values in persons living in institutions. Oddly enough, the mortality rate from arteriosclerotic causes of these County Home men in the eight years following the study was nearly three times that of the men living at home, and the mortality rate of the women all living in their own homes was only about half that of the men living in their own homes. These mortality figures are strangely contradictory of the assumed relationship between blood cholesterol levels and arteriosclerotic disease. However, the three groups are not comparable because sex is obviously a controlling factor in establishing the serum cholesterol level; the dietary regimes of the people in the County Home and of those living in their own homes were radically different, and other traumatic influences may well have been operative in the County Home group. This study was one of the first to establish the need for separate norms for blood cholesterol values of men and women.

**Wyoming women and high altitude.** At the Wyoming station 70 women over 60 years of age were studied. Their serum cholesterol levels were uniformly higher than those of the California women and were of the same order as those of the Iowa and Illinois groups. The diets of the Wyoming and California women contained the same amount of fat, but the Wyoming women had considerably more of the fat from animal sources. But the Wyoming study showed no correlation between fat intake and serum cholesterol even though a positive correlation was found between the serum cholesterol and the cholesterol of the diet. The Wyoming subjects, living at an altitude of 7200 ft., had significantly higher hemoglobin levels and a greater volume of red blood cells than did the California group who lived at sea level. They also had a good deal more overweight, 56 per cent, as compared with 24 per cent among the California women. No correlation was found, however, between overweight and blood cholesterol in either the California or Wyoming women. But such a correlation appeared when the fat and cholesterol of the diets of the California men were compared with amounts of underweight and overweight (fig. 96).

The Wyoming study was interpreted to mean that the high altitude affected blood cholesterol as well as hemoglobin. This is a new concept based on the notion that the increase in red cell count caused by altitude may be accompanied by an

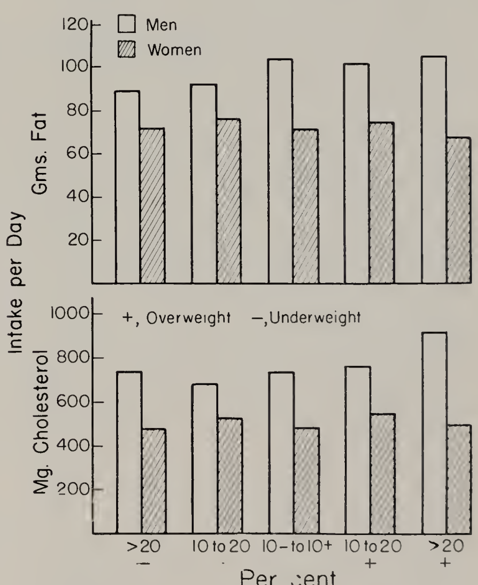



Fig. 96. Fat and cholesterol intakes of California men and women in relation to under- and overweight. Note that amounts of dietary fat and cholesterol increase with overweight in men, but not in women.

increase in the residue of broken-down "ghost" cells which contribute cholesterol to the blood. This effect of altitude was not seen when the blood values of the Colorado men and women living at 8,000 to 11,00 ft. altitude were compared with those of the same age in California. The Colorado diets were much lower in fat and cholesterol than those of the California subjects.

**The Western adolescents and altitude.** A review of the blood cholesterol levels of the adolescents examined in seven Western states might shed some light on this problem. Arizona and Idaho, at roughly 2400 ft. altitude, reported serum cholesterol for boys and girls 12 to 16 and 15 to 16 years of age, respectively, as 135 and 166 mg-per cent for boys, 145 and 175 mg-per cent for girls (table 6). But the groups are not comparable, the Arizona subjects being Papago Indian children living on a relatively marginal diet; the Idaho children were by most standards well fed and well grown. The Montana and Utah adolescents at 4000 ft. altitude differed also, with the Montana boys and girls having the low mean blood cholesterol values of 133 and 144, the same as the Arizona group, and the Utah subjects 156 and 167, almost the same as the Idaho group. Clearly altitude cannot be the dominant influence. Another comparison is seen in New Mexico at an altitude of 6400 ft. Here the two groups, one Spanish Ameri-

**TABLE 6.—Altitude Effect on Hemoglobin and Serum Cholesterol of Western Adolescents.**

| Station | Altitude—ft. above sea level | Age & Sex—years | No. of Subjects | Hemoglobin—gm. % | Serum Cholesterol—mg. % |
|---|---|---|---|---|---|
| Arizona | 2400 | 12-16 | | | |
| | | Boys | 48 | 13.7 | 135 |
| | | Girls | 46 | 12.5 | 145 |
| Idaho | 2400 | 15-16 | | | |
| | | Boys | 124 | 15.4 | 166 |
| | | Girls | 154 | 13.9 | 175 |
| Montana | 4200 | 14-16 | | | |
| | | Boys | 110 | 15.2 | 133 |
| | | Girls | 112 | 14.0 | 144 |
| Utah | 4300 | 13-19 | | | |
| | | Boys | 54 | 14.0 | 156 |
| | | Girls | 70 | 13.3 | 167 |
| New Mexico | 6400 | 14-16 | | | |
| Spanish Americans | | Boys | 48 | 14.1 | 152 |
| | | Girls | 58 | 13.5 | 164 |
| Anglos | | Boys | 28 | 15.2 | 173 |
| | | Girls | 36 | 13.8 | 187 |
| Colorado | 6000 to | Boys | 74 | 14.8 | 170 |
| | 11,000 | Girls | 74 | 14.3 | 177 |
| Washington | Sea Level | 15-16 | | | |
| | to 11,000 | Boys | 124 | 14.8 | 165 |
| | | Girls | 124 | 13.5 | 178 |

can and one Anglo, living side by side, reported quite different diets, had different rates of growth and different blood composition generaly. The Spanish-American boys and girls had serum cholesterol levels like those of children in Utah and Arizona, 152 and 164 mg-per cent. The Anglos' average levels were 173 and 187, the highest levels reported in any of the Western studies of adolescents. Perhaps the New Mexico high altitude had some effect in raising the cholesterol level of the Spanish Americans above that of the Arizona Indians and of the Anglos above those of the similarly fed and similarly developed children in Utah and Idaho. The low values of the Montana subjects are puzzling.

Colorado boys and girls at 8000 to 11,000 ft. altitude had cholesterol levels almost identical with the Idaho, New Mexican Anglos, and Washington subjects of the same age range, 14 to 16 years. Here again no consistent altitude effect can be discerned.

**Hemoglobin and cholesterol levels compared.** The hemoglobin levels in the blood follow the expected trend and are roughly paralleled by the cholesterol levels, again with the exception of the Montana values. The Arizona children had lower hemoglobin than any of the others, likewise the lowest cholesterol. The Utah, New Mexico Spanish-American, Colorado, and Washington children had the next higher hemoglobin and cholesterol values, the Spanish American equalling the Utah group in spite of relatively poorer diets, perhaps because of the influence of the higher altitude. The Idaho and New Mexico Anglo groups had the highest levels of hemoglobin and cholesterol, which were about the same even though the Idaho intake of nutrients generally exceeded that of the Anglos. Perhaps altitude was the assisting factor in the latter case. The Montana children had the expected high hemoglobin levels even though the serum cholesterols were low.

## VALUE OF CAROTENE AS PRO-VITAMIN A

The conditions which affect the transformation of carotene, the deep-orange pigment found in many fruits and vegetables, into vitamin A in the body are not clearly known, even though experiments on the subject have been carried on since 1930. This is an important problem because in many diets, especially of vegetarians, most of the vitamin A is provided as carotene. Indeed, it was assumed in the estimation of the need for vitamin A that in the American diet about two-thirds is supplied in the form of carotene.

One of the offshoots of the nutritional status project in the West was a study of this question. The Arizona station examined the effect of nonfat milk on the utilization of carotene by rats and found that in the presence of the milk a medium sized daily dose of pure carotene, 60 micrograms (1,000 micrograms = 1 milligram; 1,000 mg = 1 gm), laboratory rats were able to store more vitamin A in the liver than when the carotene was given without milk. When vitamin A itself was given instead of carotene, no difference in liver vitamin A storage due to the presence of the nonfat milk could be detected.

Alpha-tocopherol, vitamin E, was tried similarly at the California station. It had been reported elsewhere that small amounts of alpha-tocopherol given daily significantly increased the amount of vitamin A which rats could store in their livers and kidneys when carotene was fed. The California study included feeding 0.5

and 1.0 mg vitamin E daily along with large and small daily doses of pure carotene or pure vitamin A. A favorable effect of the vitamin E was found within certain narrow limits of carotene feeding, 1,200 to 2,400 micrograms total in two weeks, but not when the amounts given were above or below these crucial levels. The total amount of carotene which was transformed into vitamin A and stored never much exceeded the daily dose of carotene. On the other hand, quantitative cumulative storage of vitamin A was found when vitamin A itself was fed in doses above 75 micrograms daily, either with or without vitamin E. Apparently the growing rat uses up 75 micrograms vitamin A daily and stores the rest without reference to vitamin E, but even large daily doses of carotene are wasted with or without vitamin E. This is partly due to losses from the digestive tract.

A further study was made of the rate and site of carotene transformation to vitamin A. Vitamin A was found in the intestinal wall two hours after carotene was given either in water dispersion or in oil, and after three hours this vitamin A had disappeared from the intestinal wall and appeared in the liver, the site of permanent storage. On the whole, the role of vitamin E in making carotene a more effective source of vitamin A was not supported by these experiments, but the vast difference in availability between vitamin A from animal food sources and the carotene of vegetable foods was emphasized.

Another condition which has been suggested as important in the utilization of carotene is that of hypothyroidism or hyperthyroidism. At the California station, experiments on both rats and dogs were devised to test this. These animals can be made deficient in thyroid function by administration of certain drugs, for example, thiouracil. The thyroids enlarge, change in cellular character, and produce little of the important thyroid hormone, thyroxin. Such rats were found to store more vitamin A in the livers than did normal control rats when small carotene doses were given. But when the dose of carotene was much increased, the difference disappeared. When normal and hypothyroid rats were depleted of vitamin A, the hypothyroid animals had more liver vitamin A left than the normals, thus indicating slower utilization of stored vitamin A in the former. This could be attributable to reduced body weight gains, since normal animals limited in their food consumption likewise retained more vitamin A stores during the period of depletion. When carotene in oil was fed, it disappeared from the intestines of the partly starved, normal and hypothyroid rats at the same rate. Thus, absorption from the intestine, transformation, and utilization of carotene appeared to be the same in normal and hypothyroid animals, but slower growth and lighter weight caused by the thyroid condition reduced the utilization of the vitamin A formed and allowed more storage from the same intake of carotene.

Mature young dogs similarly treated were studied chiefly as to changes in the blood. A single dose of carotene produced a peak in the blood level of vitamin A in 8 to 11 hours in both normal and hypothyroid dogs. But in contrast to the findings in the rats, hypothyroidism alone caused a rise in the level of the serum lipids, especially carotene, vitamin A, and cholesterol. Both groups of dogs had considerable deposits of carotene in the liver as well as vitamin A, and about equal amounts of carotene and vitamin A in the adrenal glands. Two stock dogs fed large amounts of vitamin A had much larger stores of vitamin A in the liver and kidneys and much higher levels in the circulating blood than the carotene-fed experimental dogs, but their adrenals contained no carotene and only the same amount of vitamin A as the adrenals of the experimental animals. Thus there appeared to be a fixed control of the vitamin A of the adrenals only. Again, it was concluded that absorption and utilization of carotene in hypothyroid dogs was not affected by the thyroid but that the lipid levels of the blood, including cholesterol as well as vitamin A and carotene, were raised by this condition. This had been noted in humans for cholesterol but not previously for vitamin A and carotene.

The Montana station used yeast or synthetic sources of the B vitamins in testing the effect of large amounts of ascorbic acid on the utilization of carotene with rats. A sex difference was seen in the response. On 25 mg-per cent ascorbic acid daily, female rats stored more vitamin A from a given dose of carotene than did those without the ascorbic acid, but the male rats stored less. When the ascorbic acid dose was doubled, the effect disappeared. When the carotene dose was increased 3- or 4-fold, the effect on liver vitamin A storage also disappeared. Ascorbic acid, like vitamin E, is an antioxidant, and it is not surprising that the effects of large and small amounts vary radically. This has been noted earlier by the California workers for the vitamin E effects on carotene utilization.

At all levels of ascorbic acid the amount of carotene retained as liver and kidney vitamin A in both male and female animals was greater when synthetic B vitamins were fed than when yeast was used as their source. This curious discrepancy was investigated in a new series of experiments in the hope of discovering what constituent was responsible for the difference. Vitamin $B_{12}$ was present in the synthetic vitamin mixture but presumably not in the yeasts. Rats fed the same amount of carotene without vitamin $B_{12}$ were given four different yeasts as source of the B vitamins, and on three of these yeasts they stored more vitamin A than on the fourth. The vitamin A storage of the rats on these three yeasts was the same as that of the group which received the synthetic vitamin B mixture without vitamin $B_{12}$. When $B_{12}$ was added to two of the yeast diets, carotene utilization was increased, but it was not when $B_{12}$ was added to the synthetic vitamin mixture All this seemed to indicate the presence of some factor other than vitamin $B_{12}$ in one of the yeasts and in the synthetic mixture, which affected the utilization of carotene.

They next tried choline, a vitamin-like substance present in foods and in body tissues, chiefly combined with fats as phospholipids or in acetylcholine, an important compound indispensable for muscle function. When choline was added to the yeast diet, the rats stored more liver vitamin A from carotene than they did without the choline. The same was true when vitamin $B_{12}$ was fed. But on the synthetic vitamin-mix diet, choline and vitamin $B_{12}$ brought about no such improvement. The reason for this has still to be found, but it seems clear that there is something in yeast which stimulates carotene utilization when choline or vitamin $B_{12}$ is fed, but which is not effective alone. This might be concerned with the use of methionine, an important sulfur-containing amino acid, because this amino acid, as well as choline and vitamin $B_{12}$, is active in methylation, transfer of the methyl group, $CH_3$, to other physiological compounds such as creatine, cystine, or niacin.

The Montana workers also noted the effects of choline and vitamin $B_{12}$ on serum and liver cholesterol values. Adequate or nearly adequate amounts of choline were found to lower liver cholesterol and slightly increase serum cholesterol. When vitamin $B_{12}$ was fed, varying results were found. Generally there was no effect on liver cholesterol, but when it was fed along with yeast, there was an increase in blood serum cholesterol. More study of the problem is indicated.

There were three studies of carotene utilization on human subjects, namely, on preadolescent girls in Louisiana, adolescent boys and girls in Washington, and men and women over 50 years of age in California. Six girls, 8 to 9 or 11 years of age, were kept under close observation on their self-selected usual diets for six weeks and on a controlled diet for six weeks. The diets contained adequate amounts of all nutriets except vitamin A and carotene during the basal periods, and during the experimental periods 3.6 mg carotene was supplied each child daily in the form of the carotene of sweet potatoes. All fecal carotene was measured as an index of the intestinal absorption of the sweet potato carotene. In the five younger girls, the absorption was 22 to 29 per cent and in the 11-year-old girl, 39 per cent, overall average, 28 per cent.

Meanwhile, the blood serum levels for carotene were raised when the sweet potatoes were fed, although the rise was not statistically significant. The vitamin A levels of the blood were higher during the controlled diet periods, especially in the first three weeks on the basal diet, after which the addition of sweet potatoes or of nonfat milk had no effect on serum levels of either carotene or vitamin A. Some other factor in the controlled diet, perhaps protein, must have effected the rise in the vitamin A blood level preceding the addition of the sweet potatoes. The effect was possibly not changed by that addition. Here is another puzzle awaiting investigation.

The Washington station studied 248 15 and 16-year-old native-born-and-reared boys and girls in two geographical areas of that state. The 7-day diet records, blood serum levels of carotene and vitamin A, biomicroscopic study of skin and conjunctiva of the eyes, reinforced by examination of Kodachrome photographs, were used to determine the vitamin A status. There was no real difference due to age or to geographical location in the vitamin A and carotene intakes, but the boys always had greater intakes than the girls. Similarly, there were no significent differences due to age, area, or sex in the levels of blood vitamin A or carotene. Intakes were classified as excellent, but blood levels and physical signs were only fair to good. Significant correlations were found for vitamin A intake with serum carotene and serum ascorbic acid, and for carotene intake also with these two blood levels, and between the serum levels of vitamin A, carotene and ascorbic acid. The subclinical changes in skin and eye membranes did not correlate with serum levels or dietary intakes of these vitamins. The carotene levels in the blood. 106 to 117 mcg-per cent, were lower than were reported for many other adolescent groups, but vitamin A levels were somewhat higher, 44 to 46 mcg-per cent. This would indicate lower immediate intakes of carotene with high vitamin A intakes, or else good intakes of carotene and vitamin A in the past, with temporarily low values at the time of the study. Blood carotene levels and dietary carotene contents, it will be remembered, do not always indicate the fixed vitamin A status which is the result of the total dietary history. In the Washington study, the immediate intake was high in vitamin A when compared with carotene, but physical signs and blood values indicated probably lower intakes in the past.

The study of 514 older people in California showed only small declines with age in blood levels of carotene and vitamin A, no sex differences, and generally good status. The intakes of vitamin A and carotene were calculated separately, and carotene was found to average less than a third of the combined intake instead of the two-thirds usually estimated. The total intakes in International Units were high, 8 to 10 thousand daily. Positive correlations between vitamin A intake and serum vitamin A, and between carotene intake and carotene levels, were found. Thickening of the eye membranes and drying or keratinization of the skin were often found, but these changes were no more marked in those with poor than in those with good intakes and blood levels of vitamin A. Apparently advancing age had more influence on these changes than the vitamin A status.

## SOME STUDIES ON RIBOFLAVIN

**Blood riboflavin.**

Both free and total blood serum riboflavin were determined in several of the Western states (fig. 97). The values for the latter were found to be variable and much higher in the older than the younger subjects. The difference between free and total riboflavin is taken as a measure of the riboflavin combined with another compound to form an active component of one or more enzyme systems. Unlike the free and total serum cholesterol, the free and total riboflavin levels varied independently. Riboflavin is one of the B vitamins essential to the operation of many of the enzyme systems which control metabolism, and adequate intake is certainly important.

In the Idaho study of adolescents, no correlation could be found between serum--free or total riboflavin and riboflavin in the diet. This may be due to the liberal riboflavin content of the diets, since only 10 per cent of the boys and 15 per cent of the girls had less than two-thirds the recommended allowance of riboflavin. In Montana, some correlation between total blood riboflavin and dietary intake was found, but, again, convincingly only when the subjects with low intakes were included. The relationship did not hold for free riboflavin.

In Oregon, seven adult women, 24 to 44 years old, were subjects for a study of riboflavin metabolism on controlled diets containing 1.2 mg riboflavin. The daily fasting values averaged 3.21 mcg-per cent total blood serum riboflavin, and 1.41 free riboflavin, in over 200 analyses. The urinary excretions ranged from 27 to 40 per cent of the riboflavin intake. When a dose of riboflavin was given, the blood riboflavin rose to a peak in half an hour and declined to fasting value again after five hours. The peak in urinary riboflavin occurred one hour after the test dose, and by the fifth hour was back to the one-hour excretion level. Two of the seven subjects were not in equilibrium on the 1.2 mg riboflavin daily and probably needed more than this amount in their diets.

The New York group maintained three women and nine men for 42 days on 50 to 66 per cent of the recommended allowance for riboflavin, then for 32 days on 35 to 40 per cent of this allowance. The diet contained an adequate amount of protein. The average total riboflavin of red blood cells and blood serum was found to be 22.4 and 3.85 mcg-per cent, respectively, in the beginning, and only 14.6 and 2.63 at the end of the study. Nitrogen retention was determined in all

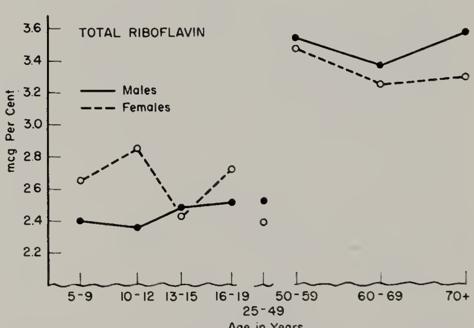



**Fig. 97. Total serum riboflavin levels of children and adults in six Western states.**

cases, too, but no relationship between this and the blood levels was found. On the whole, riboflavin excretion and nitrogen retention were inversely related. This experiment was a clear demonstration that blood levels soon reflect inadequacy of riboflavin in the diet.

**Riboflavin excretion and retention.**

In Tennessee, in connection with a 3-year study of calcium, phosphorus, and nitrogen balances on 17 college women 19 to 25 years old, riboflavin intakes and excretions were measured on restricted, supplemented, and natural food diets. The restricted diets contained no milk, eggs, or wheat, the suplemented diet had dicalcium phosphate and riboflavin added, and the natural diets had eggs, milk and wheat added. The study was prompted by interest in the widely used nonallergic diets. Riboflavin balance was maintained on the 1.0 to 1.3 mg riboflavin provided by the restricted diet, but was promptly increased when either pure riboflavin or riboflavin in eggs, milk, or wheat was added to the diet. The increase was always greater when the natural foods were added, and the subjects obviously utilized riboflavin in amounts well above the 1.4 to 1.9 mg of the recommended daily allowances.

## ACKNOWLEDGMENTS

The Research and Marketing Act of 1946 provided funds for the Agricultural Experiment Stations not only for research in agriculture and marketing but for nutrition research as well. One section of the Act reserved a specific portion of the funds for the support of cooperative research between or among two or more State Experiment Stations. These regional funds were administered by a Committee of Nine acting for the Experiment Stations through their regional groups, Northeast, North Central, South, and West.

Each of the regions established at once a series of cooperative researches, each implemented by the appointment of a Tachnical Committee containing one or more representatives from each cooperating state and usually a representative of the corresponding section of the U. S. Department of Agriculture and of the Office of Experiment Stations. Each such committee had an administrative adviser, usually an Experiment Station director.

In 1947 a good many of these cooperative research projects were set in motion. One project, that on Nutritional Status, was inaugurated in all four regions at the same time. In the South the first phase of this study was a food consumption survey, but in 1950 this region also adopted Nutritional Status as title of the project. These projects had formal numbers and titles and each of them was implemented by a corresponding contributing project set up by each of the cooperating states and by the Federal agencies. The titles and lists of cooperating states follow.

Northeast Region. Project NE 4, 1947-1952. Cooperative nutritional status studies in the Northeast region. Maine, Massachusetts, New Jersey, New York, Rhode Island, West Virginia. The objective was the correlation of dietary surveys, biochemical studies, and medical examinations.

Subcommittees on dietary methods, biochemical methods, and medical examinations tested and agreed upon suitable procedures which were then followed by all cooperating groups. Statistical methods of evaluating the results were also


**Interior and exterior views of a mobile laboratory used in Colorado during the studies reported in this bulletin.**

established for the region. The population groups studied were: Maine, junior high school students; Massachusetts, pregnant (pre- and postpartum) women; New Jersey, male industrial workers; New York, preadolescent and adolescent boys and grils; Rhode Island, high school and college students; West Virginia, college students, families, and preadolescent children.

When these studies were terminated in 1952, the new title and number NE 16 were adopted, emphasizing the effect of nutrient intake (the food supply) upon the nutritional status of human subjects, and six more stations joined in the project. More than 3700 persons were studied.

Project NE 16, 1952-1956. Relationship of nutrient intake to nutritional staus in human subjects. The cooperating stations were, Connecticut (Storrs), Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York (Cornell), Pennsylvania, Rhode Island, Vermont, West Virginia, Bureau of Human Nutrition and Home Economics (USDA).

North Central Region. Project NC 5, 1947-1957. Nutritional status and dietary needs of population groups in the North Central region. Subproject 1. The nutritional status and dietary needs of older people. This was started in 1947 by Iowa, Michigan, Minnesota, Nebraska, South Dakota, Bureau of Human Nutrition and Home Economics, and Office of Experimental Stations (USDA). In 1949 Illinois, Indiana, Missouri, and Wisconsin joined the group, and these nine stations continued the study until 1959. Subproject 2. Nutritional status of school children as influenced by the school lunch. This was begun in 1947 by Ohio, Kansas, Iowa, Bureau of Human Nutrition and Home Economics (USDA). Subproject 3. Protein and amino acid requirements in human metabolism. 1948-1952. Indiana, Michigan, Wisconsin. After 1952, Subproject 3 was incorporated in Subproject 1 and the project retitled "Nutritional status and dietary requirements of older women." Energy and protein or amino acid needs of older women were the chief subjects investigated. Subproject 2 was retitled "Nutritional status of school children." More than 5100 subjects participated in these surveys.

Southern Region. Project S 4. Family food consumption in the Southern region in certain types of farming areas. 1947-1951. Arkansas, Mississippi, South Carolina, Tennessee, Virginia, North Carolina, Bureau of Human Nutrition and Home

**A nutritionist records the amounts and kinds of foods eaten by one Iowa woman and (right) nutrients in the dietary records are calculated by workers in the Northeastern Region.**

Economics, U. S. Department of Agriculture. Project S 15. Assessment of nutritional status of humans. 1950-1956. Subproject 1. Nutritional requirements and utilization of selected nutrients. Alabama, Louisians, Mississippi, Kentucky, Tennessee, Texas, BHNHE, USDA. Subproject 2. Evaluation of means of assessing nutritional status. Georgia, Louisiana, Virginia. Preadolescent children, 6-9 and 8-11 years old, were the subjects of the first studies of status and later of controlled metabolic measurements. Nearly 900 persons were included in the studies.

Western Region. Project W 4. Subproject 1. Nutritional status and dietary needs of population groups in selected areas of the West. 1947-1958. Arizona, California, Colorado, Idaho, Montana, New Mexico, Oregon, Utah, Washington. The cooperative funds were allotted wholly or largely in the West to one, two, or three states each year, so that in the 10 years each state had the major sum twice. This made for a greater concentration of effort and production during the crucial field surveys.

A trailer laboratory and truck were loaned the region by the U. S. Public Health Service and this unit was sent first to Oregon, in 1947-48, then to California, in 1948-49, and to Colorado, Arizona, and New Mexico in 1949-50. After July, 1950, the trailer was returned to Washington, D. C., and local laboratory space was provided in Idaho and Utah, 1950-51, and in Washington and Montana, 1951-52. The trailer laboratory was especially useful in the remote areas in Arizona and in California and Colorado where space was at a premium during the year of this study. The X-ray and dental equipment was kept in the trailer and conveniently transferred from place to place over mountains and bridges during the first three years of the project. Photographs of the interior and exterior of the mobile laboratory are shown on page 117.

Several members of the team of nutritionists, biochemists, and other technicians went with the trailer during the first few years of the study. Except for California, all of the states chose to study children of high school or college age. California and Colorado examined men and women from 50 to 89 years old and Utah and Arizona groups of children 6 to 19 years old. The Arizona children were Papago Indians attending two schools. The Utah children were either former rheumatic fever patients and their parents or a matched group, none of whom had had this disease. More than 3100 men, women, and children were examined in this region.

The extent and possible nutritional origins of dental caries formed one of the main lines of inquiry in Oregon, Utah, Washington, Idaho, and Montana.

**Regional and state publications.** In the Northeast, a series of 7 regional bulletins incorporated all phases of the nutritional survey findings in a uniform and correlated manner. In addition, in that region 8 papers concerned with methods in both field and laboratory were published by two or more cooperating stations, and 30 independent papers were issued by 8 states.

In the North Central region, 7 regional bulletins incorporating the work of two or more states, 8 cooperative journal papers and 34 individual station papers from 8 states reported the primary data.

In the South, 3 regional bulletins presenting the food consumption studies were issued by six states and the Bureau of Human Nutrition and Home Economics, and 17 papers by six stations on the nutritional status data.

In the West, five regional bulletins or papers and 55 papers from nine states were published.

The total list contains 38 regional or joint bulletins or papers, and 140 independent station reports most of which have been published in scientific journals.

Nine of the reports used in compiling this bulletin were in manuscript form but had either been accepted or approved for publication. The total number of publications reviewed was 178.

All data mentioned and summaries presented as tables or graphs in this review are taken from these bulletins and papers. The compiled tables of data published in the four regions are available to those professionally interested on application to the University of California Library, Berkeley, California. The full bibliography is printed as an appendix to this Bulletin.

The Interregional Committee who sponsored this publication and who approved it on authorization by the four regional Technical Committees on Nutritional Status was made up of Pearl P. Swanson of Iowa (Chairman), Florence L. MacLeod of Tennessee, Harold H. Williams of New York (Cornell), and Clara A. Storvick of Oregon.

Assistance was rendered by the provision of additional data, photographs, and constructive suggestions by Hazel K. Stiebeling and Ruth M. Leverton, Institute of Home Economics, and Lura M. Odland, State Experiment Stations Division, U. S. D. A., M. J. Babcock of New Jersey, Mary M. Clayton of Maine, Walter Lewis of West Virginia, Susan B. Merrow of Vermont, Catherine J. Personius of New York (Cornell), Ruth Tucker of Rhode Island, Ercel Eppright, Charlotte Roderuck, and Elisabeth Willis of Iowa, Lida Burrill of South Dakota, Janice M. Smith of Illinois, Dorothy S. Moschette of Louisiana, Willamay T. Dean of Virginia, Elizabeth Dyar of Colorado, Margaret M. Hard of Washington, Edith M. Lantz of New Mexico, Ethelwyn B. Wilcox of Utah.

## PUBLICATIONS

### NE 4 and NE 16: Cooperative Nutritional Status Studies in the **Northeast Region**

### A. Regional Bulletins

**Our Code No.***

NE 12 I. Techniques—Northeast Regional Publication No. 5. Cornell University Agr. Exp. Sta. Memoir 307, Ithaca, N. Y. Mar. 1951.

NE 13 II. Physical Findings. Babcock, M. J., Bryan, A. Hughes, M. D., Clayton, Mary M., Faster, Walter D., Lawless, J. J., Tucker, Ruth, Wertz, Anne W., and Young, Charlotte M. Northeast Regional Publ. No. 8. N. J. Agr. Exp. Sta. Bull. 763, New Brunswick, N. J. June 1952.

NE 11 III. Dietary Methodology Studies. Young, Charlotte M., Chalmers, Faith W., Church, Helen N., Clayton, Mary M., Gates, Lorraine O., Hagan, Gladys C., Steele, Betty F., Tucker, Ruth E., Wertz, Anne W., and Foster, Walter D. With technical assistance of: Brine, Constance, Brown, Phyllis T., Fogler, Elaine, Franklin, Ruth E., Goff, Ruth, Higgins, Prudence S., Smudski, Vivian L., Turner, Dorothy U. and West, Rae. N. E. Regional Publ. No. 10. U. of Agr. Exp. Sta. Bull. 469, Amherst, Mass. Aug. 1952.

NE 14 IV. Dietary Findings. Tucker, Ruth E., Chalmers, Faith W., Church, Helen N., Clayton, Mary M., Foster, Walter D., Gates, Lorraine O., Hagan, Gladys C., Steele, Betty F., Wertz, Anne W., Young, Charlotte M. N. E. Regional Publ. No. 11. R. I. Agr. Exp. Sta. Bull. 319, Contribution 802, Kingston, R. I. June 1952.

*The code numbers are used in the compiled tables of data, not printed in this bulletin, but available on microfilm (see page 130).

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NE 15 V. Blood Findings. Clayton, Mary M., Babcock, M. J., Foster, W. D., Stregevsky, S., Tucker, Ruth E., Wertz, Anne W. and Williams, H. H. N. E. Regional Publ. No. 14. U. of Maine Agr. Exp. Sta. Bull. 516, Orono, Maine. May 1953.

NE 16 VI. Correlations. Babcock, M. J., Clayton, Mary M., Foster, Walter D., Lojkin, Mary E., Tucker, Ruth E., VanLandingham, H., and Young, Charlotte M. N. E. Regional Publ. No. 13. W. Va. U. Agr. Exp. Sta. Bull. 361T, Morgantown, W. Va. June 1953.

NE 1 VII. Contribution of Seven Food Groups to the Diet. Steele, Betty F., Chalmers, Faith W., Church, Helen N., Clayton, Mary M., Gates, Lorraine O., Murphy, Gladys C., Tucker, Ruth E., Wertz, Anne W., Young, Charlotte M. and Foster, Walter D. Assisted by Brine, Constance R., Brown, Phyll's T., Cornell, Marian Brooks and Randall, Shirley Wing N. E. Reg'l. Publ. No. 17. Cornell U. Agr. Exp. Sta. Memoir 333, Ithaca, N. Y. July 1954.

## B. Regional Papers

NE 53 A comparison of dietary study methods. I. Dietary history vs. seven-day record. Young, C. M., Chalmers, F. W., Church, H. N., Clayton, M. M., Tucker, R. E., Wertz, A. W. and Foster, W. D. J. Am. Dietet. A. 28:124-128, 1952.

NE 53A A comparison of dietary study methods. II. Dietary h'story vs. seven-day record vs. 24-hour recall. Young, C. M., Hagan, G. C., Tucker, R. E., and Foster, W. D. J. Am. Dietet. A. 28:218-221, 1952.

NE 54 The dietary record—how many and which days? Chalmers, F. W., Clayton, M. M., Gates, L. O., Tucker, R. E., Wertz, A. W., Young, C. M. and Foster, W. D. J. Am. Dietet. A. 28:711-717, 1952.

NE 17 Role of breakfast and of between-meal foods in adolecents' nutrient intake. Steele, B. F., Clayton, M. M., and Tucker, R. E. J. Am. Dietet. A. 28:1054, 1952.

NE 42 A referee blood experiment involving the use of microchemical methods. Clayton, M. M., Babcock, M. J., Foster, W. D., Stregevsky, S., Tucker, R. E., Wertz, A. W. and Williams, H. H. J. Nutr. 52:383-393, 1954.

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NE 56 Can different interviewers obtain comparable dietary survey data? Church, H. N., Young, C. M., Clayton, M. M. and Foster, W. D. J. Am. Dietet. A. 30:777-779, 1954.

NE 47 Examiners' ratings of color transparencies of clinical signs associated with vitamin deficienc'es. Merrow, S. B., Clayton, M. M., Newhall, C. A. and Foster, W. D. Am. J. Clin. Nutr. 5:56-61, 1957.

## C. Station Papers

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NE 44 Ascorbic acid utilization by women. Response of serum level and night urinary excretion to increasing levels of intake. Potgieter, M., Morse, E. H. and Walker, G. R. J. Nutr. 55:217-224, 1955.

NE 43A A study of the eating habits and the nutritional adequacy of the diets of thirty-three women in a State training school for mental defectives. Potgieter, M., Morse, E. H. and Walker, G. R. Am. J. Mental Def. 60:335-339, 1955.

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NE 46 Ascorbic acid utilization by women. Response of blood serum and white blood cells to increasing levels of intake in two groups of women of different age levels. Morse, E. H., Potgieter, M. and Walker, G. R. J. Nutr. 60:229-236, 1956.

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NE 57 Published vs. analyzed values for ascorbic acid. Morse, E. H., Potgieter, M. and Walker, G. R. J. Am. Dietet. A. 34:265-266, 1958.

NE 62 Ascorbic acid and cholesterol studies on women in an institution for the handicapped. Potgieter, M., Morse, E. H., Walker, G. R. and Dayton, N. A. Am. J. Mental Def. 63:325-329. 1958.

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## Maine

NE 9 Remodeling the school lunch for the teen-ager. Clayton, Mary M. and Ullman, Dorothy E. Maine Agr. Exp. Sta. Bull. 475. Aug. 1949.

NE 8 Breakfasts of Maine teen-agers. Clayton, Mary M. Maine Agr. Exp. Sta. Bull. 495 Nov. 1951.

NE 10 Food habits of Maine school children. Clayton, Mary M. Abstract of a talk presented before Am. School Food Service Assoc. meeting in N. Y. Nov. 1951. Am. J. Pub. Health 426 (No. 8), 967-968. 1952.

## Massachusetts

NE 31 Metabolism of nicotinic acid in pregnancy. Lojkin, M. E., Wertz, A. W. and Dietz, C. G. J. Nutr. 46:335-352, 1952.

NE 3 Diets of pregnant women: influence of socio-economics factors. Murphy, G. H. and Wertz, A. W. J. Am. Dietet. A. 30:34-38, 1954.

NE 52 Amino acid content of foods. Wertz, A. W., Ruttenberg, P. K., French, G. P., Murphy, B. H. and Guild, L. P. J. Am. Dietet. A. 32:926-928, 1956.

NE 41 Nutrition in pregnancy: dietary and biochemical data. Wertz, A. W., Holden, E. M., Murphy, G. C., Lojkin, M. E., Van Horn, P. S., Guild, L. P. and Dietz, C. E. Univ. of Mass. Agr. Exp. Sta. Bull. 487. 1956.

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NE 34 Simplification of the "long method" for calculating the nutritional value of diets. Babcock, M. J. New Jersey Agr. Exp. Sta. Bull. 751. Rutgers Univ., New Brunswick, N. J. June 1950.

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NE 7a Nutritional status of industrial workers. II. Effects of education, age, income and ethnic groups. Babcock, M. J.,Church, Helen N. and Gates, Lorraine O. Milbank Memorial Fund Quarterly 33:137-151, 1955.

NE 33 Methods for measuring fingernail growth rates in nutritional studies. Babcock, M. J. J. Nutr. 55:323-326, 1955.

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W 8 Nutritional status of selected adolescent children. I. Description of subjects and dietary findings. Hard, M. M. and Esselbaugh, N. C. Am. J. Clin. Nut. 4:261-268. 1956.

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W 81 Food patterns of Washington adolescent children. Hard, M. M. and Esselbaugh, N. C. Mss. approved for publ. 1959.

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W 72 Effect of altitude and diet on hematopoiesis and serum cholesterol. Payne, I. R. J. Nutr. 64:433-446. 1958.

# APPENDIX

The following are titles only of tables compiled during the research reported in this bulletin. The tables themselves have been recorded on microfilm and are available as follows:

Positive film strips for use in a microfilm reader are on deposit in the Agricultural Reference Service, University of California Library, Berkeley, and in the Library of the U. S. Department of Agriculture, in Washington, D. C. These are identified in the card catalog as follows:

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> California Agricultural Exp. Sta. October, 1959.
> Microfilm supplement, appendix tables.

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# TABLES OF DATA

| *Section of Bulletin* | | |
|---|---|---|
| 3 | Table 1. | Average amounts of foods consumed by children, in pounds per week. |
| | Table 2. | Average amounts of foods consumed by adults, in pounds per week. |
| | Table 3. | Fat intakes of children and adults in 6 North Central, 7 Western and one Southern state. |
| | Table 4. | Summary of average amounts of food consumed by children, in pounds per week. |
| 4 | Table 1. | Mean daily calorie, protein, calcium, iron and vitamin intakes of children and adolescents. |
| | Table 2. | Mean daily calorie, protein, calcium, iron and vitamin intakes of adults. |

16*m*-10,'59(H.N.Press)WP 156